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RESOURCE CONSERVATION AND RECOVERY ACT FACILITY INVESTIGATION REPORT
ZONE C VOLUME 2 SECTION 10 APPENDIX C CNC CHARLESTON SC
11/14/1997
ENSAFE INC.

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ZONE C
RCRA FACILITY
INVESTIGATION REPORT
NAVBASE CHARLESTON

VOLUME II
SECTION 10-APPENDIX C

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Revision: 0

10.0 SITE-SPECIFIC EVALUATIONS

This section presents site-specific evaluations which summarize analytical results from samples collected during the RFI at NAVBASE, expected fate and transport of COPCs, and human health-based and ecological risk assessments. This section is divided into investigatory groups that were established in the *Final Zone C RFI Work Plan* (E/A&H, November 1995).

Sampling occurred in phases as presented in Section 2, Volume 1, *Final Comprehensive RFI Work Plan*. The first round of sampling was performed per the *Final Zone C RFI Work Plan* (E/A&H, November 1995). Organic compound analytical results from the first round were compared to the USEPA Region III *Risk-Based Concentration Table, January-June 1996*, June 3, 1996 (RBCs). Inorganic analytical results were compared reference concentrations, determined as outlined in Section 5 of this report, or to RBCs where no reference concentration was available. Based on this preliminary review, some sites required further sampling and analysis to identify COPCs, define the nature and extent of any contamination, and provide additional data for the CMS. To comply with the Corrective Action Management Plan schedule, it was necessary to use unvalidated data for first-round screening.

Data Evaluation

The following screening tools and data evaluation methods were used to determine COPCs at each site:

- Surface Soil analytical results were compared to residential soil ingestion screening values in the USEPA Region III, *Risk-Based Concentration Table, January to June — June 1996*, June 3, 1996. Noncarcinogenic chemicals were adjusted to equate with an HQ of 0.1.

- Subsurface Soil analytical results were compared to soil screening levels — Transfers from Soil to Groundwater in the USEPA Region III, *Risk-Based Concentration Table, January to June — June 1996*, June 3, 1996.

- Groundwater analytical results were compared to tap water screening values of the RBCs or to the USEPA *Drinking Water Regulations and Health Advisories*, May 1995. Noncarcinogenic chemicals were adjusted to equate with an HQ of 0.1.

- Sediment and surface water results were compared to ecological screening levels as discussed in Section 8.

- TEFs were used to convert cPAHs to BEQs, which were subsequently summed for each sample and compared to the BaP RBC. Similarly, TEFs were used to convert dioxins to TEQs, which were compared to the 2,3,7,8-TCDD RBC of 1.0 μg/kg for soil and 0.4 μg/L for groundwater.

- Duplicate samples were incorporated with their respective primary samples. When either the duplicate or primary sample had a detection, the detected value was used. When both the duplicate and primary samples had detections, an average of the two concentrations was used to compensate for matrix heterogeneity.

Deviations from *Final Zone C RFI Work Plan* (E/A&H, November 1995)

Deviations from the proposed sampling in the work plan were required in some cases and are specifically noted in the investigatory group subsections. Deviations are summarized here.

Proposed samples from the lower interval were not collected in several locations due to a high water table, or due to subsurface objects (i.e., large rocks, old pilings, fill material) and utilities.

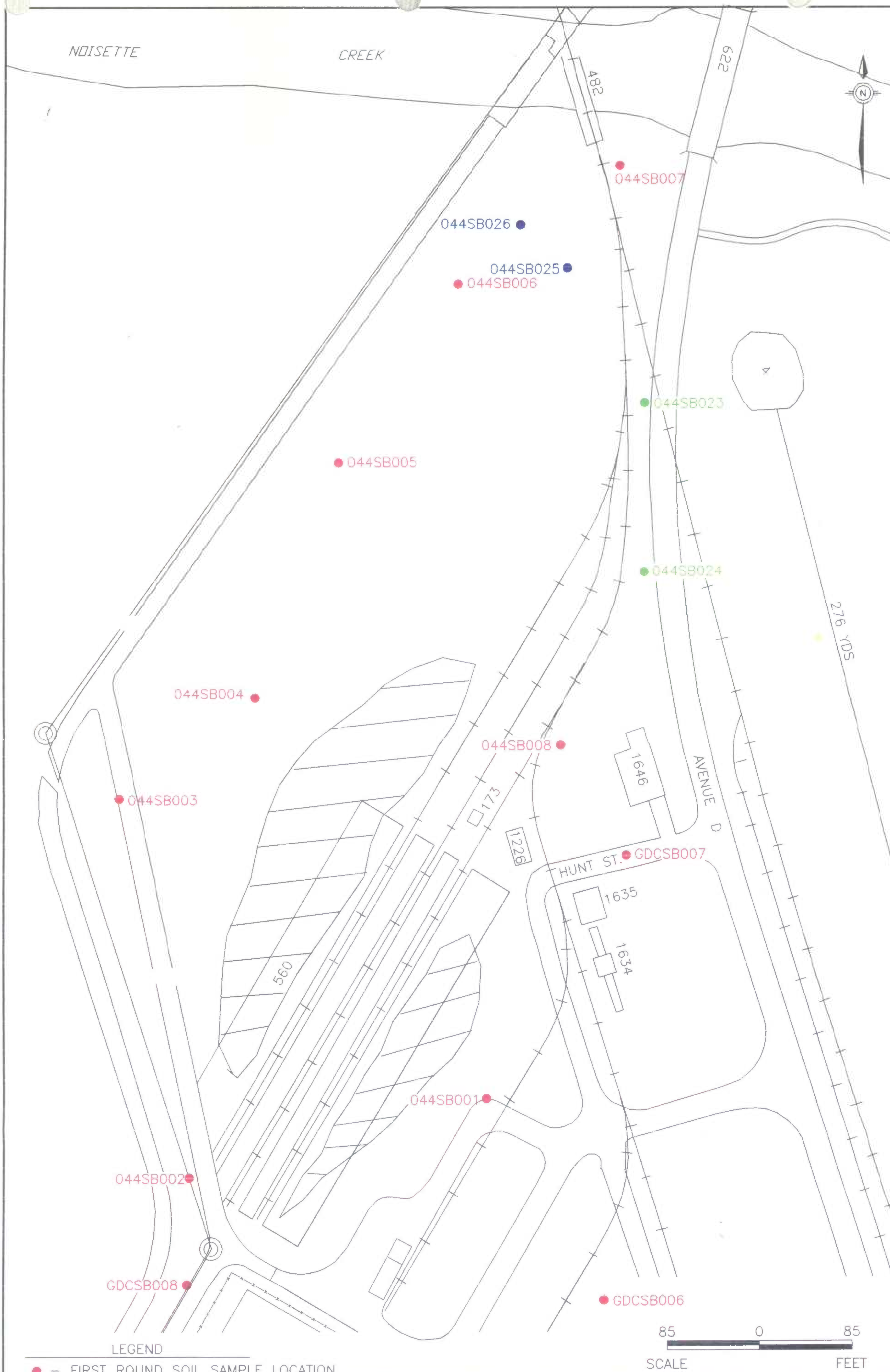
10.1 SWMU 44 – Coal Storage Area

SWMU 44 was a coal storage yard used for unloading railcars and the intermediate storage of coal before use at the steam-generation plant in Building 32. Operations began in the 1940s, but were scaled down in late 1995. Two coal piles were onsite during the field investigation, the largest of which was estimated to be 80 feet by 400 feet. The site is in the northern portion of Zone C and is bound to the west and north by Noisette Creek, to the south by a drainage ditch, and to the east by Avenue D (Figure 10.1.1). A drainage ditch also crosses the site, paralleling the railway.

Previous studies at SWMU 44 focused on surface water runoff and surface water quality. Eight sampling events conducted between 1981 and 1985, indicated metals and total suspended solids in surface water runoff and surface water samples. The results of these data warranted an RFI at SWMU 44.

An RFI was completed at SWMU 44 to assess impacts from metals and SVOCs to soil, sediment, groundwater, and/or surface water as a result of coal storage onsite. Samples were collected from each medium in areas with the highest potential for contamination, such as areas downgradient of the coal piles. All sampling was completed in accordance with the procedures outlined in the *Final Zone C RFI Work Plan* (E/A&H, November 1995). The sampling and analysis for each medium at SWMU 44 are summarized below.

The Detachment completed an interim measure in September 1996 which resulted in the removal of approximately 13,246 tons of coal and a coal/dirt mixture. The interim measure was based on a "visual" removal and no confirmation samples were collected at that time. Confirmation samples were collected in July 1997 and are discussed in Section 10.1.11.



LEGEND

- – FIRST ROUND SOIL SAMPLE LOCATION
- – SECOND ROUND SOIL SAMPLE LOCATION
- – THIRD ROUND SOIL SAMPLE LOCATION

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FIGURE 10.1.1
SWMU #44–COAL STORAGE AREA
SOIL SAMPLE LOCATIONS

DWG DATE: 10/10/97 | DWG NAME: 29CHZC14

00072G012

10.1.1 Soil Sampling and Analysis at SWMU 44

Soil was sampled in accordance with the *Final Zone C Work Plan* (E/A&H, November 1995) and Section 3 of this report in two rounds. During the first round, nine soil samples were collected from eight locations; one lower interval and eight upper interval samples. A shallow water table prohibited the collection of more lower interval samples; saturated soil samples were not submitted for analysis. Soil samples were submitted for metals and cyanide analyses at DQO Level III. One duplicate soil sample was submitted for Appendix IX analyses at DQO Level IV, which includes the parameters listed above as well as herbicides, hexavalent chromium, organophosphorous pesticides, and dioxins. Table 10.1.1 summarizes the first-round soil sampling and analysis.

Table 10.1.1
First Round – Soil Sampling and Analysis
SWMU 44 – Coal Storage Area

Interval	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
Upper	8	8	Metals and Cyanide	Metals and Cyanide	None
Lower	8	1	Metals and Cyanide	Metals and Cyanide	Shallow water table; saturated soil samples were not submitted for analyses.

First-round soil data were compared to the USEPA Region III *Risk-Based Concentration Table*; June 1996. This preliminary review indicated arsenic at concentrations exceeding its RBC. Two upper interval sample locations were added for the second round to delineate arsenic contamination. Second-round samples were submitted for metals analysis. Table 10.1.2 summarized the second-round sampling and analysis.

Table 10.1.2
Second Round – Soil Sampling and Analysis Summary
SWMU 44 – Coal Storage Area

Interval	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Collected	Deviations
Upper	0	2	Metals	Metals	Added
Lower	0	0	None	None	None

10.1.2 Nature and Extent of Soil Contamination at SWMU 44

Soil analytical results for organics are in Table 10.1.3, and results for inorganics are in Table 10.1.4. Appendix D is a complete analytical report for Zone C, and Appendix H contains detection only summary tables.

Table 10.1.3
Organic Compound Analytical Results for Soil
SWMU 44 – Coal Storage Area

Compound	Sample Interval	Frequency of Detection	Range of Detection	Mean	RBC[a]	Number of Samples Exceeding RBC
Volatile Organic Compounds (μg/kg) **(1 Sample collected and analyzed from upper interval)**						
Toluene	Upper	1/1	1.0	NA	1,600,000	0
Semivolatile Organic Compounds (μg/kg) **(1 Sample collected and analyzed from upper interval)**						
Acenaphthylene	Upper	1/1	75.0	NA	470,000	0
Anthracene	Upper	1/1	63.0	NA	2,300,000	0
Benzo(a)anthracene	Upper	1/1	460.0	NA	880[b]	0
Benzo(a)pyrene	Upper	1/1	500.0	NA	88[b]	1
Benzo(b)fluoranthene	Upper	1/1	1500.0	NA	880[b]	1
Benzo(k)fluoranthene	Upper	1/1	1300.0	NA	8,800[b]	0
Chrysene	Upper	1/1	530.0	NA	8,800[b]	0
1-Methylnaphthalene	Upper	1/1	110.0	NA	31,000	0
2-Methylnaphthalene	Upper	1/1	91.0	NA	31,000	0

Table 10.1.3
Organic Compound Analytical Results for Soil
SWMU 44 – Coal Storage Area

Compound	Sample Interval	Frequency of Detection	Range of Detection	Mean	RBC[a]	Number of Samples Exceeding RBC
Dibenzofuran	Upper	1/1	43.0	NA	31,000	0
Fluoranthene	Upper	1/1	660.0	NA	310,000	0
Naphthalene	Upper	1/1	97.0	NA	310,000	0
Phenanthrene	Upper	1/1	210.0	NA	230,000	0
Pyrene	Upper	1/1	510.0	NA	230,000	0
BEQ	Upper	1/1	709.53	NA	88	1
Pesticide and PCB Compounds (μg/kg) (1 Sample collected and analyzed from upper interval)						
Aldrin	Upper	1/1	1.4	NA	38	0
Chlordane	Upper	1/1	2.4	NA	490	0
Pesticide and PCB Compounds (1 Sample collected and analyzed from upper interval)						
Endosulfan sulfate	Upper	1/1	0.43	NA	47,000	0
Endrin aldehyde	Upper	1/1	15.0	NA	230	0
Heptachlor	Upper	1/1	3.9	NA	140	0
Heptachlor Epoxide	Upper	1/1	1.2	NA	70	0
Dioxin Compounds (ng/kg) (1 Sample collected and analyzed from upper interval)						
1234678-HpCDD	Upper	1/1	138.58	NA	NA	NA
1234678-HpCDF	Upper	1/1	20.089	NA	NA	NA
123478-HxCDF	Upper	1/1	4.5	NA	NA	NA
1234789-HpCDF	Upper	1/1	1.03	NA	NA	NA
123678-HxCDD	Upper	1/1	2.795	NA	NA	NA
123789-HxCDD	Upper	1/1	2.894	NA	NA	NA
234678-HxCDF	Upper	1/1	0.857	NA	NA	NA
OCDD	Upper	1/1	1288.568	NA	NA	NA
OCDF	Upper	1/1	50.816	NA	NA	NA
TEQ	Upper	1/1	4.04	NA	1,000	NA

Table 10.1.3
Organic Compound Analytical Results for Soil
SWMU 44 – Coal Storage Area

Compound	Sample Interval	Frequency of Detection	Range of Detection	Mean	RBC[a]	Number of Samples Exceeding RBC
Herbicide Compounds (μg/kg) **(1 Sample collected and analyzed from upper interval)**						
2,4,5-Trichlorophenoxyacetate acid	Upper	1/1	28.0	NA	78,000	0

Notes:
[a] = Noncarcinogenic RBCs were adjusted to equate to an HQ of 0.1.
[b] = These compounds are cPAHs and were multiplied by the appropriate TEF for comparison as BEQs.
All results are in micrograms per kilogram (μg/kg), except for dioxins, which are in nanograms per kilogram (ng/kg).

Table 10.1.4
Inorganic Analytical Results for Soil
SWMU 44 – Coal Storage Area

Analyte	Sample Interval	Frequency of Detection	Range of Detection (mg/kg)	Mean (mg/kg)	Reference Conc. (mg/kg)	Number of Samples Exceeding Reference
Aluminum	Upper	12/12	1,240 - 36,600	8,827.08	9,990	2
	Lower	1/1	28,900	NA	23,700	1
Antimony	Upper	2/12	0.85 - 1.10	0.98	0.55	2
Arsenic	Upper	11/12	1.3 - 103.0	22.23	14.2	3
	Lower	1/1	12.3	NA	14.1	0
Barium	Upper	12/12	6.7 - 426.00	59.82	77.2	0
	Lower	1/1	37.4	NA	68.5	0
Beryllium	Upper	9/12	0.16 - 2.00	0.75	ND	9
	Lower	1/1	1.3	NA	0.98	1
Cadmium	Upper	8/12	0.09 - 3.60	0.87	0.65	3
	Lower	1/1	1.2	NA	0.28	1
Calcium	Upper	12/12	2030 - 164,500	35,131.67	NA	NA
	Lower	1/1	5,700	NA	NA	NA
Chromium	Upper	12/12	3.4 - 61.5	23.87	26.4	3
	Lower	1/1	43.7	NA	12.5	1

Table 10.1.4
Inorganic Analytical Results for Soil
SWMU 44 – Coal Storage Area

Analyte	Sample Interval	Frequency of Detection	Range of Detection (mg/kg)	Mean (mg/kg)	Reference Conc. (mg/kg)	Number of Samples Exceeding Reference
Cobalt	Upper	12/12	0.88 - 13.60	4.99	3.22	8
	Lower	1/1	7.9	NA	7.1	1
Copper	Upper	11/12	6.5 - 207.0	54.09	34.7	5
	Lower	1/1	37.1	NA	42.2	0
Iron	Upper	12/12	2,420 - 99,500	16378.33	NA	NA
	Lower	1/1	29,700	NA	NA	NA
Lead	Upper	12/12	1.7 - 156.9	50.27	330	0
	Lower	1/1	46.0	NA	73.2	0
Magnesium	Upper	12/12	245 - 5,780	???	NA	NA
	Lower	1/1	4,170	NA	NA	NA
Manganese	Upper	12/12	34.0 - 408.0	111.64	92.5	5
	Lower	1/1	171.0	NA	106	1
Mercury	Upper	8/12	0.120 - 0.87	0.33	0.24	4
	Lower	1/1	0.460	NA	0.30	1
Nickel	Upper	12/12	2.4 - 43.4	16.34	12.3	6
	Lower	1/1	13.6	NA	16.7	0
Potassium	Upper	12/12	156 - 8,610	1413.75	NA	0
	Lower	1/1	2,660	NA	NA	0
Selenium	Upper	8/12	0.64 - 8.80	2.11	1.44	2
	Lower	1/1	1.8	NA	2.90	0
Silver	Upper	1/12	0.08	NA	ND	1
Sodium	Upper	10/12	162 - 90,300	1,435.3	NA	NA
	Lower	1/1	458.0	NA	NA	NA
Tin	Upper	6/12	1.00 - 23.70	5.7	2.95	3

Table 10.1.4
Inorganic Analytical Results for Soil
SWMU 44 – Coal Storage Area

Analyte	Sample Interval	Frequency of Detection	Range of Detection (mg/kg)	Mean (mg/kg)	Reference Conc. (mg/kg)	Number of Samples Exceeding Reference
Vanadium	Upper	12/12	3.8 - 68.20	18.90	23.4	2
	Lower	1/1	71.7	NA	56.9	1
Zinc	Upper	12/12	6.4 - 279	101.95	159	2
	Lower	1/1	132.0	NA	243	0
Cyanide	Upper	1/8	4.3	NA	ND	1

Volatile Organic Compounds in Soil

Toluene was the only VOC detected and it was below its RBC.

Semivolatile Organic Compounds in Soil

Fourteen SVOCs were detected; however, only two compounds – BaP and benzo(b)fluoranthene (both cPAHs) – exceeded their RBCs of 88.0 μg/kg and 880.0 μg/kg, respectively. The BEQ calculated for soil sample location 044SB007 was 710 μg/kg which exceeded the RBC of 88.0 μg/kg for BaP.

Pesticides and PCBs in Soil

Six pesticide compounds were detected in the duplicate soil sample; however, all were below their respective RBCs. No PCBs were detected in the duplicate soil sample collected at SWMU 44.

Other Organic Compound Analyses for Soil

Other organic compounds include the Appendix IX compound groups that are not part of the standard analytical suite, including herbicides, organophosphorous pesticides, and dioxins.

One herbicide was detected below its RBC of 78,000 μg/kg in the duplicate soil sample from SWMU 44. Organophosphorous pesticides and hexavalent chromium were not detected. Nine dioxins were detected. The TCDD TEQ was 4.04 ng/kg which is below the RBC of 1,000 ng/kg.

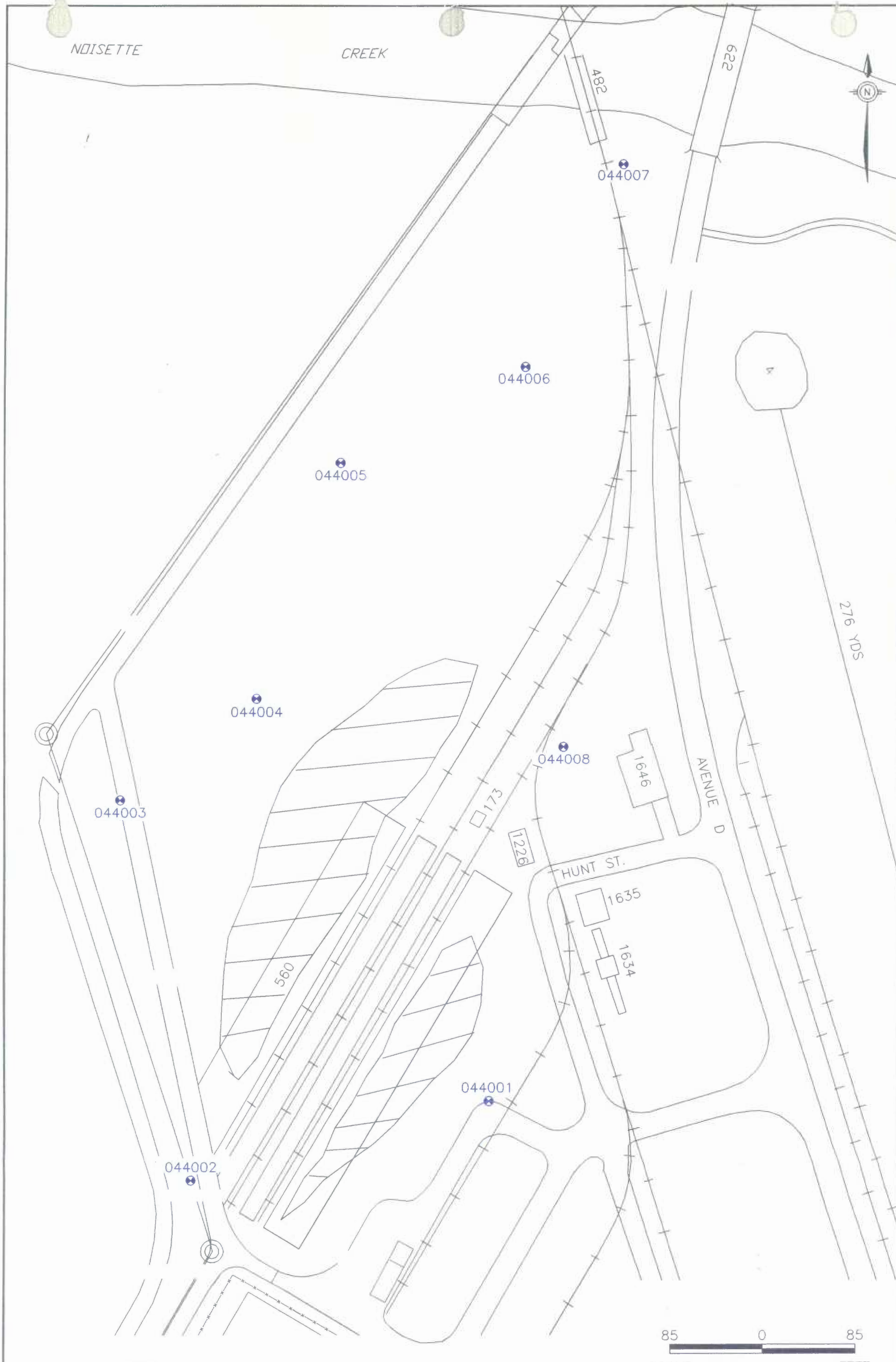
Metals and Cyanide in Soil

Twenty-four analytes were detected in soil at SWMU 44. Table 10.1.4 summarizes the inorganic analytical results. Sixteen analytes were detected in the upper interval; eight were detected in the lower interval above their respective reference concentrations. Twenty-one analytes were detected at a high frequency (greater than six detections of the 12 samples analyzed) in the upper interval. Since only one lower interval sample was collected, a similar comparison could not be made.

Cyanide was detected in one soil sample (044CB00701) at 4.3 mg/kg, which is below its RBC of 160 mg/kg. Hexavalent chromium was not detected in soil samples collected at SWMU 44.

10.1.3 Groundwater Sampling and Analysis at SWMU 44

Eight monitoring wells were installed to assess the shallow groundwater at SWMU 44 (Figure 10.1.2). Sampling and analyses were completed in accordance with the *Final Zone C RFI Work Plan* (E/A&H, November 1995). Groundwater samples were submitted for metals and cyanide analysis at DQO Level III. One duplicate groundwater sample was submitted for Appendix IX analyses at DQO Level IV, which includes the parameters listed above and herbicides, hexavalent chromium, organophosphorous pesticides, and dioxins. Additionally, a duplicate sample collected from 044MW006 was submitted for analysis of VOCs, SVOCs, pesticide/PCBs, sulfate, and TDS. Table 10.1.5 summarizes the groundwater sampling and analysis. Detected concentrations in groundwater will be further evaluated based on additional groundwater data collected during the subsequent three quarters of sampling. The data are discussed in the Section 11.



LEGEND

⊗ - SHALLOW MONITORING WELL

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FIGURE 10.1.2
SWMU #44-COAL STORAGE AREA
SHALLOW MONITORING WELL
LOCATIONS

DWG DATE: 10/03/97 | DWG NAME: 29CHZC17

000726022

Table 10.1.5
Groundwater Sampling and Analysis
SWMU 44 – Coal Storage Area

Interval	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
Shallow	8	8	Metals and Cyanide	Metals and Cyanide	None

10.1.4 Nature and Extent of Groundwater Contamination at SWMU 44

Analytical results for organic compounds are summarized in Table 10.1.6, and inorganic analytes in Table 10.1.7. A complete analytical report of Zone C is in Appendix D, and Appendix H contains detection only summary tables.

Table 10.1.6
Organic Compound Analytical Results for Shallow Groundwater
SWMU 44 – Coal Storage Area

Compound	Frequency of Detection	Range of Detection	Tap Water RBC[a]	Number of Samples Exceeding RBCs
Semivolatile Organic Compounds (μg/L)				
Acetophenone	1/1	1.0	0.0042	1
Bis(2-ethylhexyl) phthalate	1/1	8.0	4.8	1
Dioxins in Groundwater (pg/L)				
1234678-HpCDD	1/1	5.384	NA	NA
123789-HxCDF	1/1	3.29	NA	NA
OCDD	1/1	163.737	NA	NA
OCDF	1/1	2.855	NA	NA
TEQ	1/1	0.549	NA	NA

Note:
[a] = Noncarcinogenic RBCs were adjusted with an HQ of 0.1.

Table 10.1.7
Inorganic Analytical Results for Groundwater
SWMU 44 – Coal Storage Area

Compound	Frequency of Detection	Range of Detection (μg/L)	Mean (μg/L)	Background Conc. (μg/L)	Number of Samples Exceeding Background
Aluminum	8/8	119 - 38,000	5,969.25	410	7
Antimony	2/8	3.3 - 3.9	3.60	ND	2
Arsenic	4/8	3.9 - 15.3	10.78	6.07	3
Barium	8/8	6.4 - 60.2	39.38	16.7	7
Beryllium	1/8	21.9	21.90	0.33	1
Calcium	8/8	85,000 - 447,000	305,250.00	NA	NA
Chromium	8/8	1.30 - 7.10	3.31	1.99	6
Cobalt	4/8	0.96 - 75.5	34.29	1.33	3
Copper	7/8	2.0 - 18.2	7.80	1.9	7
Iron	8/8	851 - 239,000	43,370.13	NA	NA
Lead	8/8	2.2 - 19.8	7.14	3.27	5
Magnesium	8/8	23,200 - 653,000	161,025.00	NA	NA
Manganese	8/8	418 - 1,990	1,189.38	608	7
Nickel	8/8	2.0 - 221.0	42.24	3.59	4
Potassium	8/8	7,170 - 282,000	81,955.75	NA	NA
Selenium	1/8	7.2	7.20	ND	1
Sodium	8/8	13,200 - 4,640,000	975,875.00	NA	NA
Vanadium	5/8	6.3 - 26.0	11.04	1.96	5
Zinc	8/8	18.1 - 608.0	191.96	13.2	8

Note:
[a] = Noncarcinogenic RBCs were adjusted with an HQ of 0.1.

Volatile Organic Compounds in Groundwater

No VOCs were detected in groundwater samples from SWMU 44.

Semivolatile Organic Compounds in Groundwater

Three SVOCs were detected in the duplicate sample — benzoic acid, acetophenone, and bis(2-ethylhexyl)phthalate (BEHP). Both acetophenone and BEHP exceeded their tap water RBCs of 0.0042 μg/L and 4.8 μg/L, respectively.

Pesticides and PCBs in Groundwater

No pesticides or PCB compounds were detected in groundwater samples from SWMU 44.

Other Organics in Groundwater

Other organic compounds include the Appendix IX compound groups that are not part of the standard analytical suite, including herbicides, organophosphorous pesticides, and dioxins.

No herbicides or organophosphorous pesticides were detected in groundwater samples from SWMU 44. Four dioxin compounds were detected in groundwater.

Inorganic Analytes in Groundwater

Nineteen inorganic analytes were detected in groundwater samples from SWMU 44. Table 10.1.8 summarizes these analytical results. Thirteen analytes were detected at concentrations above their respective reference concentration: aluminum, arsenic, barium, beryllium, chromium, cobalt, copper lead, manganese, nickel, selenium, vanadium, and zinc. Aluminum, barium, copper, manganese, and nickel exceeded their reference concentration in seven of eight samples analyzed. Zinc exceeded its reference concentration in all samples analyzed. Hexavalent chromium was not detected in groundwater. Turbidity measurements were generally below 10 NTUs for all of the monitoring wells.

10.1.5 Sediment Sampling and Analysis

Sediment was sampled in accordance with the *Final Zone C RFI Work Plan* (E/A&H, November 1995). Sediment samples were collected from 13 locations in one round (Figure 10.1.3). Sampling locations were selected relative to the downgradient runoff patterns associated with the coal pile, which were believed to represent the area most likely to have been impacted if a release had occurred. Sediment samples were collected from 0 to 6 inches. At sediment sample location 044M0013, a surface water sample could not be collected at that location because the area was dry. A surface water sample designated 044W0013 was collected at a different location as shown on Figure 10.1.4. No sample was collected at location 044M0022; the top 6 inches recovered was coal. As shown in Table 10.1.8, nine sediment samples were analyzed for metals, cyanide, and TOC; four sediment samples were analyzed for TOC and grain size only.

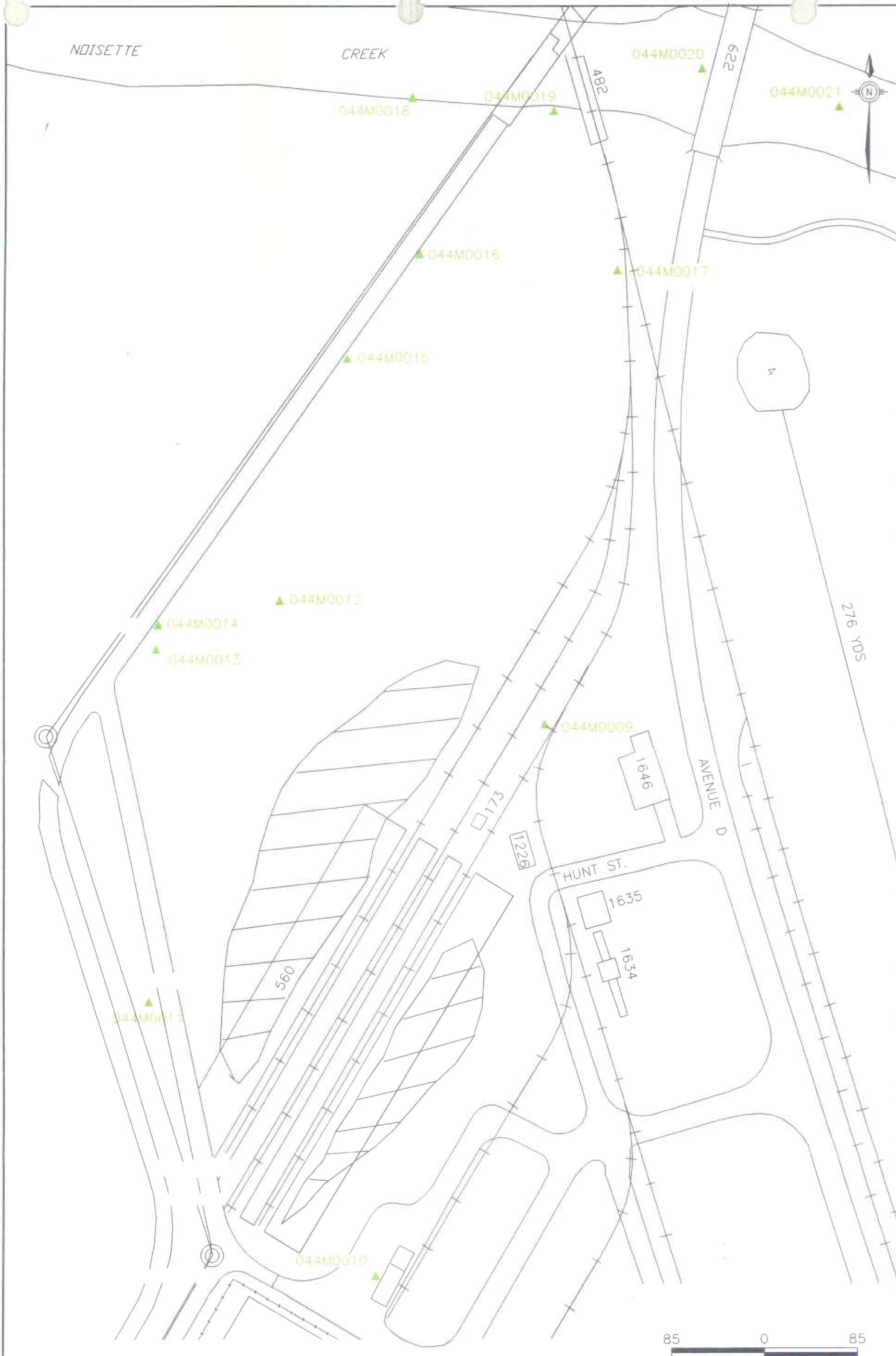
Table 10.1.8
Sediment Sampling and Analysis Summary
SWMU 44 – Coal Storage Area

Interval	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
Upper	14	13*	metals, cyanide, TOC, grain size	metals, cyanide, TOC, grain size	Sample not collected at 044M0022; sediment not recoverable.

Note:
At four of the sediment sample locations, the samples were analyzed for TOC and grain size only.

10.1.6 Nature and Extent of Sediment Contamination

Sediment samples were collected to assess any impact SWMU 44 may have on ecological receptors. Because ecological sub-zones may encompass several SWMUs and AOCs, site-specific comparisons to ecological risk-based screening levels are not appropriate. As a result, concentrations in sediment are compared to ecological sediment screening values in Section 8,



LEGEND

▲ – SEDIMENT SAMPLE

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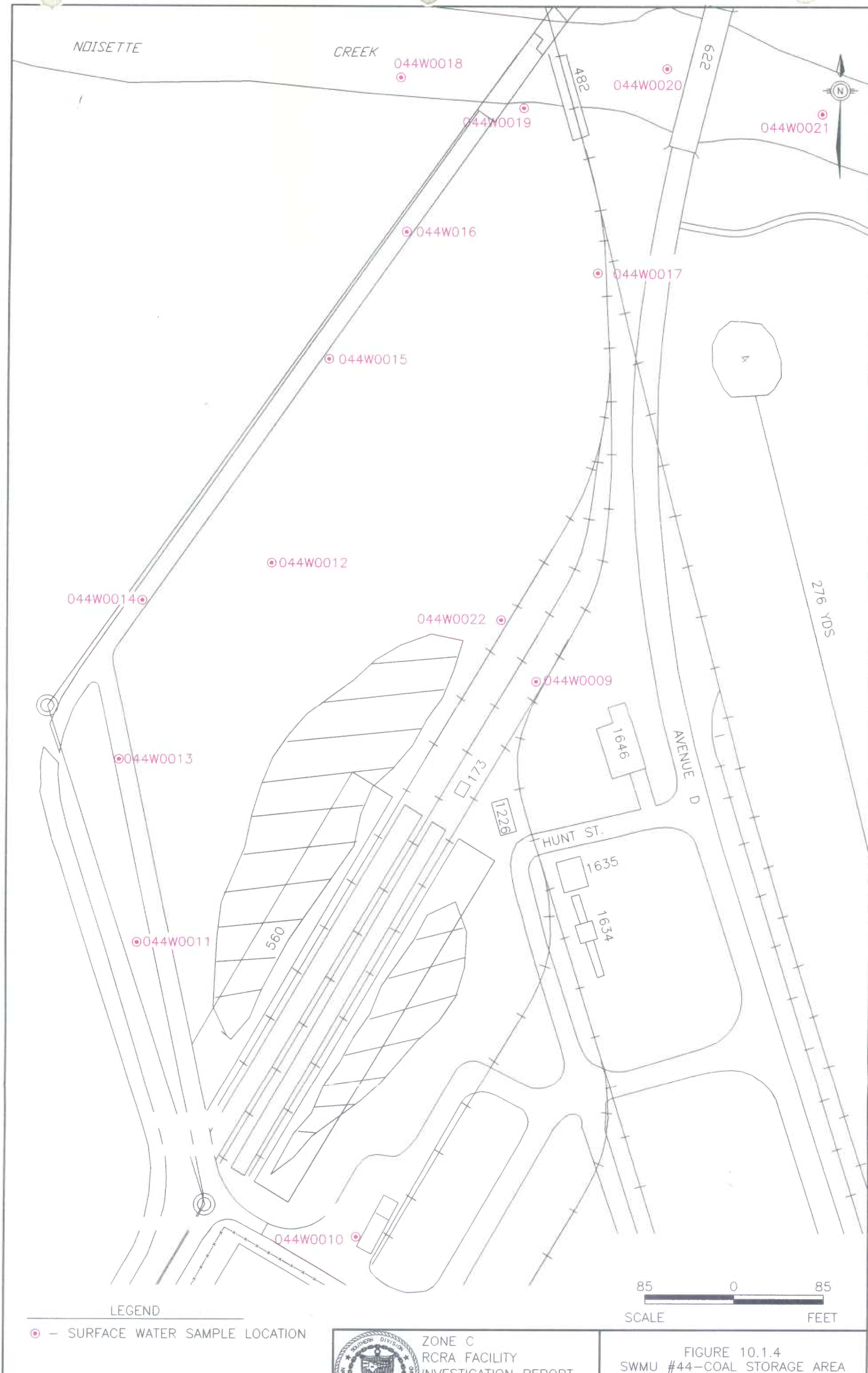
FIGURE 10.1.3
SWMU #44–COAL STORAGE AREA
SEDIMENT SAMPLE LOCATIONS

DWG DATE: 10/03/97 | DWG NAME: 29CHZC16

00072GB32



LEGEND

⊙ – SURFACE WATER SAMPLE LOCATION

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FIGURE 10.1.4
SWMU #44–COAL STORAGE AREA
SURFACE WATER SAMPLE LOCATIONS

DWG DATE: 10/03/97 | DWG NAME: 29CHZC15

Ecological Risk Assessment, and data summaries only are provided in Table 10.1.9. Appendix D is a complete analytical data report for all samples collected in Zone C.

10.1.7 Surface Water Sampling and Analysis

Surface water was sampled in accordance with the *Final Zone C RFI Work Plan* (E/A&H, November 1995). Samples were collected in one round from the 14 locations as proposed in the work plan (Figure 10.1.4). Surface water samples were collected from the 0- to 1-foot interval below the water surface, from areas most likely to have been impacted if a release had occurred.

Table 10.1.9
Inorganic Analytical Results for Sediments
SWMU 44 – Coal Storage Area

Analyte	Frequency of Detection[a]	Range of Detection (mg/kg)	Mean (mg/kg)
Aluminum	9/9	345 - 10,900	5,672.78
Antimony	5/9	0.53 - 1.20	0.78
Arsenic	9/9	4.0 - 137.0	47.00
Barium	9/9	10.5 - 70.7	36.61
Beryllium	2/9	0.45 - 0.65	0.55
Cadmium	5/9	0.04 - 0.84	0.42
Calcium	9/9	274 - 23,300	6,396.67
Chromium	9/9	8.5 - 42.1	22.94
Cobalt	9/9	1.6 - 11.6	4.16
Copper	9/9	7.2 - 75.3	34.29
Iron	9/9	5,160 - 93,700	33,454.44
Lead	9/9	11.2 - 63.6	35.42
Magnesium	9/9	39.5 - 2,090	946.17
Manganese	8/9	36.9 - 104.0	71.79

Table 10.1.9
Inorganic Analytical Results for Sediments
SWMU 44 – Coal Storage Area

Analyte	Frequency of Detection[a]	Range of Detection (mg/kg)	Mean (mg/kg)
Mercury	6/9	0.17 - 1.60	0.59
Nickel	9/9	3.8 - 26.7	10.69
Potassium	9/9	107 - 8,240	1,655.78
Selenium	7/9	0.83 - 9.30	4.95
Sodium	7/9	355 - 5,860	1,816.71
Thallium	6/9	0.67 - 4.60	2.40
Vanadium	9/9	8.1 - 33.5	20.00
Zinc	9/9	7.7 - 125.0	61.48

Note:
[a] = Noncarcinogenic RBCs were adjusted with an HQ of 0.1.

These locations were typically downgradient of the runoff patterns from the coal pile. Seven samples were analyzed for metals only, and seven samples were analyzed for metals, cyanide, organotins, pesticides/PCBs, SVOCs, and VOCs. Table 10.1.10 summarizes the surface water sampling and analysis for SWMU 44.

Table 10.1.10
Surface Water Sampling and Analysis Summary
SWMU 44 – Coal Storage Area

Interval	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
Upper	14	14	Standard Suite[a], organotins	Standard Suite[a], organotins	None

Note:
[a] = Standard Suite includes VOCs, SVOCs, metals, cyanide, and pesticide/PCBs.

10.1.8 Nature and Extent of Surface Water Contamination

Surface water samples were collected to assess any impact SWMU 44 may have on ecological receptors. Because ecological sub-zones may encompass several SWMUs and AOCs, site-specific comparisons to ecological risk-based screening levels are not appropriate. As a result, surface water concentrations are compared to ecological screening values in Section 8, Ecological Risk Assessment. Data are summarized in Tables 10.1.11 and 10.1.12. Appendix D is a complete analytical data report for all samples collected in Zone C.

10.1.9 Fate and Transport Assessment

Migration pathways investigated for SWMU 44 include soil-to-groundwater, groundwater-to-surface water, surface soil-to-air, and surface soil-to-sediment. Environmental media sampled as part of the SWMU 44 RFI include surface soil, subsurface soil, sediment, shallow groundwater, and surface water. It should be recognized that the comprehensiveness of this assessment is limited by the analyses performed. Only one soil sample was analyzed for an extensive list of organic parameters, thus the observations and conclusions regarding all but inorganic constituents should be considered in this light.

10.1.9.1 Soil-to-Groundwater Cross-Media Transport

Table 10.1.13 compares constituent concentrations detected in both soil and groundwater to groundwater protection risk-based SSLs tapwater RBCs, and grid-based background reference concentrations. Four constituents (aluminum, antimony, arsenic, and manganese) were detected at concentrations above background reference concentrations or groundwater protection SSLs in SWMU 44 soil and above tap water RBCs or background reference concentrations in SWMU 44 shallow groundwater. This indicates a potential impact to the shallow aquifer based on soil concentrations of these inorganic elements. Barium, chromium, cobalt, copper, mercury, selenium, tin, thallium, and vanadium were detected in soil above the grid-based background reference concentration or groundwater protection SSL but were not detected in shallow

Table 10.1.11
Organic Compound Analytical Results for Surface Water
SWMU 44 – Coal Storage Area

Compound	Frequency of Detection	Range of Detection (μg/L)
Volatile Compounds		
Acrolein	1/7	1.0
Semivolatile Compounds		
Acetophenone	1/7	1.0
Organotin Compounds		
Dibutyltin	1/4	0.12
Monobutyltin	1/4	0.17

Notes:
All results are in micrograms per liter (μg/L).

Table 10.1.12
Inorganic Analytical Results for Surface Water
SWMU 44 – Coal Storage Area

Analytes	Frequency of Detection	Range of Detection (μg/L)	Mean (μg/L)
Aluminum	10/14	175 - 16,400	4,795.40
Antimony	5/14	2.4 - 5.2	3.30
Arsenic	5/14	6.2 - 144.0	35.42
Barium	14/14	1.9 - 75.2	19.69
Beryllium	3/14	1.35 - 5.2	3.29
Cadmium	1/14	0.70	NA
Calcium	14/14	38,350 - 262,000	124,203.57
Chromium	14/14	1.6 - 52.4	6.95
Cobalt	8/14	0.93 - 71.0	23.94
Copper	10/14	4.9 - 92.5	22.85
Iron	14/14	359 - 85,900	14,102.14
Lead	7/14	3.8 - 9.2	5.44
Magnesium	14/14	1,615 - 373,000	154,091.79
Manganese	14/14	18.8 - 2,110	402.73
Nickel	11/14	2.5 - 107.0	33.56
Potassium	14/14	710 - 197,000	79,206.36
Selenium	6/14	4.6 - 10.4	7.57
Sodium	14/14	3,245 - 2,910,000	1,159,218.21
Vanadium	14/14	0.62 - 6.9	2.34
Zinc	14/14	5.3 - 202.0	61.79

Table 10.1.13
Chemicals Detected in Surface Soil, Subsurface Soil, Sediment, Groundwater and Surface Water
Comparison to Groundwater Protection SSLs, Tap Water RBCs, Background UTLs, and Saltwater AWQC
NAVBASE-Charleston, Zone C, SWMU 44
arleston, South Carolina

Parameter	Surface Soil Maximum Conc.	Subsurface Soil Maximum Conc.	Sediment Maximum Conc.	Ground Water Protection SSL or UTL *	Soil Units	Ground-water Maximum Conc.	Surface Water Maximum Conc.	Tap Water RBC or UTL *	Salt Water AWQC or UTL*	Water Units	Soil Conc. Exceeds SSL or UTL	Ground-water Conc. Exceeds RBC or UTL	Ground-water Conc. Exceeds SW AWQC
Acenaphthene	75	ND	ND	57000	UG/KG	ND	ND	220	9.7	UG/L	NO	NO	NO
Acetophenone	ND	ND	ND	0.7	UG/KG	1	ND	0.0042	NA	UG/L	NO	YES	NA
Acrolein	ND	ND	ND	290	UG/KG	ND	1	73	0.55	UG/L	NO	NO	NO
Aldrin	1.4	ND	ND	500	UG/KG	ND	ND	0.004	0.13	UG/L	NO	NO	NO
Aluminum	17500	28900	10900	23700	MG/KG	38000	16400	3700	NA	UG/L	YES	YES	NA
Anthracene	63	ND	ND	1200000	UG/KG	ND	ND	1100	NA	UG/L	NO	NO	NA
Antimony	1.1	ND	1.2	0.55	MG/KG	3.9	5.2	1.5	NA	UG/L	YES	YES	NA
Arsenic	103	12.3	137	29	MG/KG	15.3	1.44	6.07	36	UG/L	YES	YES	NO
Barium	426	37.4	70.7	1600	MG/KG	60.2	75.2	260	NA	UG/L	NO	NO	NA
Benzoic acid	ND	ND	ND	40000	UG/KG	2	ND	15000	NA	UG/L	NO	NO	NA
Benzo(a)pyrene Equivalents													
Benzo(a)pyrene	500	ND	ND	8000	UG/KG	ND	ND	0.0092	NA	UG/L	NO	NO	NA
Benzo(a)anthracene	460	ND	ND	2000	UG/KG	ND	ND	0.092	NA	UG/L	NO	NO	NA
Benzo(b)fluoranthene	1500	ND	ND	5000	UG/KG	ND	ND	0.092	NA	UG/L	NO	NO	NA
Benzo(k)fluoranthene	1300	ND	ND	49000	UG/KG	ND	ND	0.92	NA	UG/L	NO	NO	NA
Chrysene	530	ND	ND	160000	UG/KG	ND	ND	9.2	NA	UG/L	NO	NO	NA
Beryllium	2	1.3	0.65	63	MG/KG	21.9	5.2	0.33	NA	UG/L	NO	YES	NA
alpha-BHC	1.1	ND	ND	0.5	UG/KG	ND	ND	0.011	1400	UG/L	YES	NO	NO
beta-BHC	1.1	ND	ND	3	UG/KG	ND	ND	0.037	NA	UG/L	NO	NO	NA
Cadmium	3.6	1.2	0.84	8	MG/KG	ND	0.7	1.8	9.3	UG/L	NO	NO	NO
Chlordane	2.4	ND	ND	10000	UG/KG	ND	ND	0.052	0.004	UG/L	NO	NO	NO
Chromium	61.5	43.7	42.1	38	MG/KG	6.35	52.4	18	50	UG/L	YES	NO	NO
Cobalt	8.6	7.9	11.6	7.1	MG/KG	75.5	71	220	NA	UG/L	YES	NO	NA
Copper	207	37.1	75.3	42.2	MG/KG	18.2	92.5	150	2.9	UG/L	YES	NO	YES
Cyanide	4.3	ND	ND	NA	MG/KG	ND	ND	73	1	UG/L	YES	NO	NO
4,4'-DDD	4	ND	ND	16000	UG/KG	ND	ND	0.28	0.025	UG/L	NO	NO	NO
4,4'-DDT	4	ND	ND	32000	UG/KG	ND	ND	0.2	0.001	UG/L	NO	NO	NO
Dibenzofuran	43	ND	ND	12000	UG/KG	ND	ND	15	NA	UG/L	NO	NO	NA
Dibutyltin	ND	ND	ND	NA	UG/KG	ND	0.115	0.11	NA	UG/L	NO	NO	NA
Di-n-butylphthalate	ND	ND	ND	2300000	UG/KG	ND	2	370	3.4	UG/L	NO	NO	NO
Dieldrin	1.7	ND	ND	4	UG/KG	ND	ND	0.0042	0.0019	UG/L	NO	NO	NO
Dioxin (TCDD TEQ)	4.04	ND	ND	4000	PG/G	ND	ND	0.5	0.01	PG/L	NO	NO	NO
Endosulfan	6.13	ND	ND	1800	UG/KG	ND	ND	22	0.0087	UG/L	NO	NO	NO
Endrin	2.8	ND	ND	1000	UG/KG	ND	ND	1.1	0.0023	UG/L	NO	NO	NO
Endrin aldehyde	15	ND	ND	1000	UG/KG	ND	ND	1.1	NA	UG/L	NO	NO	NA
bis(2-Ethylhexyl)phthalate	ND	ND	ND	3600000	UG/KG	8	ND	4.8	NA	UG/L	NO	YES	NA
Fluoranthene	660	ND	ND	430000	UG/KG	ND	ND	150	1.6	UG/L	NO	NO	NO
Heptachlor	5.1	ND	ND	23000	UG/KG	ND	ND	0.0023	0.0036	UG/L	NO	NO	NO
Lead	156	46	63.6	330	MG/KG	19.8	9.2	15	8.5	UG/L	NO	YES	YES
Manganese	165	171	1.4	106	MG/KG	1990	2110	608	NA	UG/L	YES	YES	NA
Mercury	0.865	0.46	1.6	0.3	MG/KG	ND	ND	1.1	0.025	UG/L	YES	NO	NO
Methoxychlor	4	ND	ND	160000	UG/KG	ND	ND	18	0.03	UG/L	NO	NO	NO
Methylene chloride	15	ND	ND	20	UG/KG	ND	ND	4.1	2560	UG/L	NO	NO	NO
1-Methylnaphthalene	110	ND	ND	51000	UG/KG	ND	ND	150	NA	UG/L	NO	NO	NA
2-Methylnaphthalene	91	ND	ND	51000	UG/KG	ND	ND	150	NA	UG/L	NO	NO	NA
Monobutyltin	ND	ND	ND	4400	UG/KG	ND	0.173	0.11	NA	UG/L	NO	NO	NA
Naphthalene	97	ND	ND	8400	UG/KG	ND	ND	150	23.5	UG/L	NO	NO	NO
Nickel	43.4	13.6	26.7	130	MG/KG	221	107	73	8.3	UG/L	NO	YES	YES
Phenanthrene	210	ND	ND	100000000	UG/KG	ND	ND	150	NA	UG/L	NO	NO	NA
Pyrene	510	ND	ND	420000	UG/KG	ND	ND	110	NA	UG/L	NO	NO	NA
Selenium	8.8	1.8	9.3	5	MG/KG	7.2	10.4	18	71	UG/L	YES	NO	NO

Table 10.1.13
Chemicals Detected in Surface Soil, Subsurface Soil, Sediment, Groundwater and Surface Water
Comparison to Groundwater Protection SSLs, Tap Water RBCs, Background UTLs, and Saltwater AWQC
NAVBASE-Charleston, Zone C, SWMU 44
'rleston, South Carolina

Parameter	Surface Soil Maximum Conc.	Subsurface Soil Maximum Conc.	Sediment Maximum Conc.	Ground Water Protection SSL or UTL *	Soil Units	Ground-water Maximum Conc.	Surface Water Maximum Conc.	Tap Water RBC or UTL *	Salt Water AWQC or UTL*	Water Units	Soil Conc. Exceeds SSL or UTL	Ground-water Conc. Exceeds RBC or UTL	Ground-water Conc. Exceeds SW AWQC
Silver	0.08	ND	ND	34	MG/KG	ND	ND	18	0.23	UG/L	NO	NO	NO
Tin	11.85	ND	ND	2.95	MG/KG	ND	ND	2200	NA	UG/L	YES	NO	NA
Thallium	2.4	ND	4.6	0.7	MG/KG	ND	ND	0.29	21.3	UG/L	YES	NO	NO
Toluene	1	ND	ND	12000	UG/KG	ND	ND	75	37	UG/L	NO	NO	NO
Vanadium	42	71.7	33.5	600	MG/KG	26	6.9	26	NA	UG/L	NO	NO	NA
Zinc	277.8	132	125	1200	MG/KG	608	202	1100	86	UG/L	NO	NO	YES

Notes:

* - See Table 6-2
NA - Not available
ND - Not detected
SSL - Groundwater protection soil screening level
UTL - Grid-based background upper tolerance limit
RBC - Tap water risk-based concentration
MG/KG - Milligram per kilogram
UG/KG - Micrograms per kilogram
UG/L - Micrograms per liter
AWQC - Ambient Water Quality Criteria

groundwater above the tap water RBC. This indicates that soil concentrations of these inorganic elements are protective of the shallow aquifer in terms of protecting overall groundwater quality. Alpha-BHC was detected in SWMU 44 surface soil at concentrations above the groundwater protection SSL, but was not detected in SWMU 44 subsurface soil or shallow groundwater. This indicates that soil concentrations of alpha-BHC are protective of the shallow aquifer.

Aluminum, antimony, arsenic, and manganese were detected above tap water RBCs or background reference concentrations in SWMU 44 shallow groundwater. Most frequently detected were arsenic, detected above its tap water RBC in four of eight shallow groundwater samples, and manganese, detected above its background reference concentration in seven of eight shallow groundwater samples. Review of SPLP data of sample 044SB00601 revealed no leachable elements at concentrations above tap water RBCs. SPLP results support the conclusion that soil-to-groundwater migration of aluminum, and antimony is isolated in nature. Naturally occurring manganese common to estuarine environments may be more responsible for concentrations in SWMU 44 shallow groundwater than the soil-to-groundwater migration mechanism.

A possible explanation for observed shallow aquifer impacts relates to coal storage. Runoff/leachate from coal can have low pH resulting conversion of sulfur compounds to sulfuric acid. This acidity in turn can lead to enhanced migration of metals which are generally more soluble at low pH. The coal itself represents a significant source of those inorganics detected in proximal soil and groundwater at SWMU 44. As a result, the metals detected were not unexpected based upon past site use.

It should be mentioned that an interim removal action was performed subsequent to RFI sampling. A significant area of piled coal and coal/soil mix was excavated. As a result, the most obvious contamination source no longer exists and the groundwater condition would be expected to naturally improve as equilibria shift toward a neutral pH and acid solubilized metals repartition and/or precipitate.

10.1.9.2 Groundwater-to-Surface Water Cross-Media Transport

Fourteen constituents (aluminum, antimony, arsenic, barium, beryllium, chromium, cobalt, copper, lead, manganese, nickel, selenium, vanadium, and zinc) were detected in both groundwater and surface water samples. Many of the surface water samples were collected from drainage features onsite. Inorganic elements detected in surface water collected from these drainage features may have originated from surface soil rather than from groundwater migration. To evaluate groundwater-to-surface water migration, a sample collected from monitoring well 044MW007, near Noisette Creek, was examined. This shallow groundwater sample had concentrations of aluminum, arsenic, barium, chromium, copper, lead, manganese, nickel, vanadium, and zinc. Only copper was detected in monitoring well 044MW007 at a concentration above the salt water chronic AWQC. These findings suggest that copper transfer from groundwater to surface water may be a significant process for SWMU 44 with regard to ecological impacts. Additional discussion of surface water with respect to ecological impacts is included in Section 8, Ecological Risk Assessment.

Nine constituents (acetophenone, aluminum, antimony, arsenic, beryllium, BEHP, lead, manganese, and nickel) were detected in SWMU 44 shallow groundwater above tap water RBCs or background reference concentrations. Arsenic exceeds the tap water RBC in four of eight groundwater samples. Exceedances for all other chemicals are isolated to only one or two monitoring wells. To focus on the ability of these constituents to increase their areal extent, travel-time analysis was performed. Of the constituents detected in SWMU 44 groundwater above tap water RBCs or background reference concentrations, acetophenone is considered the most mobile. Groundwater travel time from 044MW006, the monitoring well with detected acetophenone, to Noisette Creek is estimated to be 17 years. The retardation factor for acetophenone based on a K_{oc} value of 35, and on the parameters for Zone C soil (total porosity of 35%, TOC of 0.006, and a bulk density of 1.67 kg/m^3) is 2. This increases the travel time to Noisette Creek for acetophenone to 34 years.

10.1.9.3 Soil-to-Air Cross-Media Transport

Table 10.1.14 lists the VOCs detected in surface soil samples collected at SWMU 44 along with corresponding soil-to-air volatilization screening levels. The maximum VOCs' surface soil concentration did not exceed its corresponding soil-to-air volatilization screening level. As a result, the soil-to-air migration pathway would not be expected to be significant at the site.

10.1.9.4 Surface Soil-to-Sediment Cross-Media Transport

Sediment samples were collected from SWMU 44 drainage ditches, pits, and depressions. Aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, nickel, selenium, vanadium, and zinc were detected in both surface soil and sediment samples collected at SWMU 44. It is likely that surface soil erosion and coal pile runoff is contributing to the concentrations of these constituents in sediment. However, future impacts are not expected because an interim removal action after the RFI eliminated the most significant of these sources. Additional discussion on the significance of sediment with respect to ecological receptors is included as necessary in Section 8, Ecological Risk Assessment for SWMU 44.

10.1.9.5 Fate and Transport Summary

Table 10.1.15 summarizes the constituents and migration pathways found to be significant for SWMU 44.

Table 10.1.14
Soil-to-Air Volatilization Screening Analysis
NAVBASE - Charleston Zone C, SWMU 44
Charleston, South Carolina

VOCs	Maximum Concentratio in Surface Soil	Soil to Air SSL *	Units	Exceeds SSL
Toluene	0.001	650	MG/KG	NO

* - Soil-to-air RBCs were obtained from USEPA Soil Screening Guidance: Technical Background Document, May 1996.

Table 10.1.15
Significant Migration Pathways
\VBASE-Charleston, Zone C, SWMU 44
Charleston, South Carolina

Parameter	Soil to Groundwater Migration	Groundwater to Surface Water Migration	Surface Soil to Sediment Migration *
Acetophenone		X	
Acetophenone		X	
Aluminum			X
Antimony			X
Arsenic	X	X	X
Barium			X
Beryllium			X
Chromium			X
Copper		X**	X
Lead			X
Manganese	X		X
Mercury			X
Selenium			X
Vanadium			X
Zinc			X

* Potential surface soil to sediment migration is based on a qualitative evaluation. The significance of constituents detected in sediment with respect to ecological impacts is addressed in Section 10.1 Ecological Risk Assessment

** - Migration pathways is considered significant due to potential ecological impacts

10.1.10 Human Health Risk Assessment

10.1.10.1 Site Background and Investigative Approach

SWMU 44 was investigated to assess soil, sediment, shallow groundwater, and surface water potentially affected by site activities. SWMU 44 was the coal storage yard which began operations in the 1940s. It is used for unloading coal railcars and for the intermediate storage of coal before use at the steam-generation plant (Building 32). According to aerial photographs, the coal storage yard is in an area that has been filled with dredge material in the past. The primary structure in the storage yard is a trestle upon which railroad cars are parked while unloading. Coal was unloaded through the bottom of the railcars onto concrete pads beneath and on either side of the trestle, and transferred away from the trestle by crane. No berms are present to contain or control storm water runoff from either coal pile.

Ten soil samples were collected from the upper interval. Table 10.1.16 lists the analytical methods used for the corresponding samples. The number of soil samples differs for various groups of analytes because specific groups of analytes were targeted at certain sample locations and/or sampling rounds. Thirteen sediment samples were collected from the upper interval. These sediment samples were collected from ditches, pits, stagnant pools and Noisette Creek tidal flats. Table 10.1.17 provides a list of the analytical methods used for the corresponding samples. As with soil, the number of sediment samples differs for various groups of analytes because specific groups were targeted at certain sample locations and/or sampling rounds. Groundwater samples collected from eight shallow monitoring wells were analyzed for a list of parameters similar to that for soil samples. The groundwater analytes are listed in Table 10.1.18. Fourteen surface water samples were collected from ditches, pits, stagnant pools, and Noisette Creek as part of the SWMU 44 RFI. Table 10.1.19 lists the methods used to analyze surface water samples.

Table 10.1.16
Methods Run at SWMU 44 - Coal Storage Area
Surface Soil

Site	Location	Metal	SVOA	VOA	Cn	Hexa	Diox	Oppe	Herb	Pest	Tph	Otin	Eng
044	B001	Y			Y								
044	B002	Y			Y								
044	B003	Y			Y								
044	B004	Y			Y								
044	B005	Y			Y								
044	B006	Y			Y								Y
044	B007	D	Y	Y	D	Y	Y	Y	Y	Y			
044	B008	Y			Y								
044	B023	Y											
044	B024	Y											

METHODS:

Metal: TAL (Target Analyte List) Metals plus tin:
Methods: 6000/7000 Series
VOA: Volatile Organic Analysis: Method 8240
SVOA: Semi-volatile Organic Analysis: Method 8270
Cn: Cyanide (Soil: Method 9010, Water: Method 9012)
Hexa: Hexavalent Chromium: Method 7195
Diox: Dioxins
Oppe: Organophosphate Pesticides:
Method 8140
Herb: Chlorinated Herbicides: Method 8150
Pest: Chlorinated Pesticides: Method 8080
Tph: Total Petroleum Hydrocarbons
Otin: Organotin
Eng: Engineering Parameters

KEY:

Y: Analyzed for standard list
D: Duplicate Analysis
IR: Method 4181
DR: Extraction Method 3550, GC Method 8100
GR: Extraction Method 5030, GC Method 8015
Blank value indicates this method of analysis was not performed

Table 10.1.17
Methods Run at SWMU 44 - Coal Storage Area
Sediment, Sampling Interval 1

Site	Location	Metal	SVOA	VOA	Cn	Hexa	Diox	Oppe	Herb	Pest	Tph	Otin	Eng
044	0009	Y											Y
044	0010	Y											Y
044	0011	Y											Y
044	0012	Y											Y
044	0013	Y											Y
044	0014	Y											Y
044	0015	Y											Y
044	0016	Y											Y
044	0017	Y											Y
044	0018												Y
044	0019												D
044	0020												Y
044	0021												Y

METHODS:

Metal: TAL (Target Analyte List) Metals plus tin:
Methods: 6000/7000 Series
VOA: Volatile Organic Analysis: Method 8240
SVOA: Semi-volatile Organic Analysis: Method 8270
Cn: Cyanide (Soil: Method 9010, Water: Method 9012)
Hexa: Hexavalent Chromium: Method 7195
Diox: Dioxins
Oppe: Organophosphate Pesticides:
Method 8140
Herb: Chlorinated Herbicides: Method 8150
Pest: Chlorinated Pesticides: Method 8080
Tph: Total Petroleum Hydrocarbons
Otin: Organotin
Eng: Engineering Parameters

KEY:

Y: Analyzed for standard list
D: Duplicate Analysis
IR: Method 4181
DR: Extraction Method 3550, GC Method 8100
GR: Extraction Method 5030, GC Method 8015
Blank value indicates this method of analysis was not performed

Table 10.1.18
Methods Run at SWMU 44 - Coal Storage Area
Shallow Groundwater, Sampling Round 1

Site	Location	Metal	SVOA	VOA	Cn	Hexa	Diox	Oppe	Herb	Pest	Tph	Otin	Eng
044	W001	Y			Y								
044	W002	Y			Y								
044	W003	Y			Y								
044	W004	D	Y	Y	D		Y	Y	Y	Y			Y
044	W005	Y			Y								
044	W006	Y	Y	Y	Y					Y			Y
044	W007	Y			Y								
044	W008	Y			Y								

METHODS:

- Metal: TAL (Target Analyte List) Metals plus tin: Methods: 6000/7000 Series
- VOA: Volatile Organic Analysis: Method 8240
- SVOA: Semi-volatile Organic Analysis: Method 8270
- Cn: Cyanide (Soil: Method 9010, Water: Method 9012)
- Hexa: Hexavalent Chromium: Method 7195
- Diox: Dioxins
- Oppe: Organophosphate Pesticides: Method 8140
- Herb: Chlorinated Herbicides: Method 8150
- Pest: Chlorinated Pesticides: Method 8080
- Tph: Total Petroleum Hydrocarbons
- Otin: Organotin
- Eng: Engineering Parameters

KEY:

- Y: Analyzed for standard list
- D: Duplicate Analysis
- IR: Method 4181
- DR: Extraction Method 3550, GC Method 8100
- GR: Extraction Method 5030, GC Method 8015

Blank value indicates this method of analysis was not performed

Table 10.1.19
Methods Run at SWMU 44 - Coal Storage Area
Surface Water

Site	Location	Metal	SVOA	VOA	Cn	Hexa	Diox	Oppe	Herb	Pest	Tph	Otin	Eng
044	0009	Y											
044	0010	D											
044	0011	Y											
044	0012	Y											
044	0013	Y											
044	0014	Y	Y	Y	Y					Y			
044	0015	Y											
044	0016	Y	Y	Y	Y					Y			
044	0017	Y											
044	0018	Y	Y	Y	Y					Y		Y	
044	0019	D	D	D	D					D		D	
044	0020	Y	Y	Y	Y					Y		Y	
044	0021	Y	Y	Y	Y					Y		Y	
044	0022	Y	Y	Y	Y					Y			

METHODS:

- Metal: TAL (Target Analyte List) Metals plus tin: Methods: 6000/7000 Series
- VOA: Volatile Organic Analysis: Method 8240
- SVOA: Semi-volatile Organic Analysis: Method 8270
- Cn: Cyanide (Soil: Method 9010, Water: Method 9012)
- Hexa: Hexavalent Chromium: Method 7195
- Diox: Dioxins
- Oppe: Organophosphate Pesticides: Method 8140
- Herb: Chlorinated Herbicides: Method 8150
- Pest: Chlorinated Pesticides: Method 8080
- Tph: Total Petroleum Hydrocarbons
- Otin: Organotin
- Eng: Engineering Parameters

KEY:

- Y: Analyzed for standard list
- D: Duplicate Analysis
- IR: Method 4181
- DR: Extraction Method 3550, GC Method 8100
- GR: Extraction Method 5030, GC Method 8015

Blank value indicates this method of analysis was not performed

10.1.10.2 COPC Identification

Soil

Based on the screening comparisons shown in Table 10.1.20 and discussed in Section 7 of this RFI, the following COPCs were identified at SWMU 44 for the surface soil exposure pathways: aluminum, arsenic, BEQs, beryllium, chromium, manganese, and thallium. Wilcoxon rank sum test analyses did not result in the inclusion of additional inorganic elements.

Sediment

Based on the screening comparisons shown in Table 10.1.21 and discussed in Section 7 of this RFI, the following COPCs were identified at SWMU 44 for the sediment exposure pathways: aluminum, arsenic, beryllium, chromium, manganese, and thallium. Wilcoxon rank sum test analyses did not result in the inclusion of additional inorganic elements.

Groundwater

As shown in Table 10.1.22, the COPCs identified in shallow groundwater for this combined site, based on first-quarter results are: TEQs, acetophenone, aluminum, antimony, arsenic, beryllium, bis(2-ethylhexyl)phthalate, lead, manganese, and nickel. Results of the Wilcoxon rank sum test did not identify any additional inorganics as shallow groundwater COPCs.

Surface Water

Surface water results were preliminarily screened using tap water RBCs. As shown in Table 10.1.23, arsenic, aluminum, antimony, beryllium, chromium, manganese, and nickel were tentatively identified as COPCs by this screening process. No surface water reference concentrations have been derived for Zone C or other areas along Noisette Creek and adjacent tidal flats and drainage features. Concentrations of arsenic, beryllium, and nickel generally appear to be elevated relative to levels that could be expected in unaffected natural surface water. Soil and sediment results for SWMU 44 indicate a nonnatural source of each surface water COPC

Table 10.1.20
Summary of Chemicals Present in Site Samples, SWMU 44
Surface Soil
NAVBASE - Charleston, Zone C
Charleston, South Carolina

NAME	CONC UNITS	FREQ	DETECTS Min	DETECTS Max	DETECTS Avg	SCREENING Value	SCREENING # Over	SCREENING Source	NON-DETECTS Min	NON-DETECTS Max	BACKGROUND Value	BACKGROUND # Over
Carcinogenic PAHs												
Benzo(a)pyrene Equiv.	UG/KG	1 - 1	710	710	710.00	88	1	C				
Benzo(a)pyrene	UG/KG	1 - 1	500	500	500.00							
Benzo(k)fluoranthene	UG/KG	1 - 1	1300	1300	1300.00							
Benzo(a)anthracene	UG/KG	1 - 1	460	460	460.00							
Benzo(b)fluoranthene	UG/KG	1 - 1	63	63	63.00							
Chrysene	UG/KG	1 - 1	530	530	530.00							
Dioxins												
Dioxin Equiv.	NG/KG	1 - 1	4.041	4.041	4.04	1000						
1234678-HpCDD	NG/KG	1 - 1	138.58	138.58	138.58							
1234789-HpCDF	NG/KG	1 - 1	1.03	1.03	1.03							
1234678-HpCDF	NG/KG	1 - 1	20.089	20.089	20.09							
123678-HxCDD	NG/KG	1 - 1	2.795	2.795	2.80							
123789-HxCDD	NG/KG	1 - 1	2.894	2.894	2.89							
234678-HxCDF	NG/KG	1 - 1	0.857	0.857	0.86							
123478-HxCDF	NG/KG	1 - 1	4.5	4.5	4.50							
OCDD	NG/KG	1 - 1	1288.568	1288.568	1288.57							
OCDF	NG/KG	1 - 1	50.816	50.816	50.82							
Inorganics												
Aluminum (Al)	MG/KG	10 - 12	1240	17500	6000.00	7800	2	N			9990	2
Antimony (Sb)	MG/KG	2 - 10	0.85	1.1	0.98	3.1		N	0.21	0.6	0.55	2
Arsenic (As)	MG/KG	10 - 10	1.3	103	23.70	0.43	10	C			14.2	6
Barium (Ba)	MG/KG	10 - 10	7	55.4	29.40	550		N			77.2	
Beryllium (Be)	MG/KG	7 - 10	0.22	2	0.67	0.15	7	C	0.1	0.24		
Cadmium (Cd)	MG/KG	7 - 10	0.09	3.6	0.88	3.9		N	0.05	0.41	0.65	2
Calcium (Ca)	MG/KG	10 - 10	1350	165000	37200.00	NA						
Chromium (Cr)	MG/KG	10 - 10	3.4	61.5	22.50	39	2	N			26.4	3
Cobalt (Co)	MG/KG	10 - 10	0.88	8.6	4.07	470		N			3.22	8
Copper (Cu)	MG/KG	9 - 10	6.5	207	60.70	310		N	1	1	34.7	3
Cyanide (CN)	MG/KG	1 - 8	4.3	4.3	4.30	160		N	0.55	1.3		

Table 10.1.20
Summary of Chemicals Present in Site Samples, SWMU 44
Surface Soil
NAVBASE - Charleston, Zone C
Charleston, South Carolina

NAME	CONC UNITS	FREQ	DETECTS Min	DETECTS Max	DETECTS Avg	SCREENING Value	SCREENING # Over	SCREENING Source	NON-DETECTS Min	NON-DETECTS Max	BACKGROUND Value	BACKGROUND # Over
Iron (Fe)	MG/KG	10 - 10	2420	99500	16100.00	NA		N				
Lead (Pb)	MG/KG	10 - 10	1.7	156.85	46.08	400		j			330	
Magnesium (Mg)	MG/KG	10 - 10	245	3800	1200.00	NA						
Manganese (Mn)	MG/KG	10 - 10	34	165	73.30	180	2	N			92.5	3
Mercury (Hg)	MG/KG	6 - 10	0.12	0.865	0.38	2.3		N	0.11	0.21	0.24	3
Nickel (Ni)	MG/KG	10 - 10	2.4	43.4	14.50	160		N			12.3	5
Potassium (K)	MG/KG	10 - 10	156	8610	1290.00	NA						
Selenium (Se)	MG/KG	7 - 10	0.64	8.8	2.31	39		N	0.48	0.51	1.44	2
Silver (Ag)	MG/KG	1 - 10	0.08	0.08	0.08	39		N	0.05	0.15		
Sodium (Na)	MG/KG	8 - 10	162	3240	840.00	NA			130	150		
Thallium (Tl)	MG/KG	1 - 10	2.4	2.4	2.40	0.63	1		0.49	0.68		
Tin (Sn)	MG/KG	6 - 10	1	11.85	3.73	4700			0.87	2	2.95	3
Vanadium (V)	MG/KG	10 - 10	3.8	42	15.10	55		N			23.4	1
Zinc (Zn)	MG/KG	10 - 10	6.4	278	87.90	2300		N			159	2
Chlorinated Pesticides												
Aldrin	UG/KG	1 - 1	1.4	1.4	1.40	38		C				
Chlordane	UG/KG	1 - 1	2.4	2.4	2.40	490		C				
Endosulfan sulfate	UG/KG	1 - 1	0.43	0.43	0.43	47000		N				
Endrin aldehyde	UG/KG	1 - 1	15	15	15.00	2300		h				
Heptachlor	UG/KG	1 - 1	3.9	3.9	3.90	140		C				
Heptachlor epoxide	UG/KG	1 - 1	1.2	1.2	1.20	70		C				
2,4,5-T	UG/KG	1 - 1	28	28	28.00	78000		N				
Semivolatile Organics												
Acenaphthylene	UG/KG	1 - 1	75	75	75.00	470000		e				
Anthracene	UG/KG	1 - 1	63	63	63.00	2300000		N				
Dibenzofuran	UG/KG	1 - 1	43	43	43.00	31000		N				
Fluoranthene	UG/KG	1 - 1	660	660	660.00	310000		N				
1-Methylnaphthalene	UG/KG	1 - 1	110	110	110.00	310000		n				
2-Methylnaphthalene	UG/KG	1 - 1	91	91	91.00	310000		n				
Naphthalene	UG/KG	1 - 1	97	97	97.00	310000		N				

Table 10.1.20
Summary of Chemicals Present in Site Samples, SWMU 44
Surface Soil
NAVBASE - Charleston, Zone C
Charleston, South Carolina

NAME	CONC UNITS	FREQ		DETECTS Min	DETECTS Max	Avg	SCREENING Value	# Over	Source	NON-DETECTS Min	NON-DETECTS Max	BACKGROUND Value	# Over
Phenanthrene	UG/KG	1 -	1	210	210	210.00	310000		n				
Pyrene	UG/KG	1 -	1	510	510	510.00	230000		N				
Volatile Organics													
Toluene	UG/KG	1 -	1	1	1	1.00	1600000		N				

Notes:

- * Retained as a chemical of potential concern
- C The RBC is based on carcinogenic effects
- N The RBC is based on noncarcinogenic effects
- j Screening level is set equal to the soil action level
- h The RBC for endrin is used as a surrogate
- e The RBC for acenaphthalene is used as a surrogate
- n The RBC for naphthalene is used as a surrogate

Table 10.1.21
SWMU 44 - Coal Storage Area
Sediment, Sampling Interval 1

Parameter	Units	Frequency of Detection	Range of Nondetected Upper Bounds	Range of Detected Concentrations	Average Detected Conc.	Screening[a] Conc.	Num. Over Screen	Reference Conc.	Num. Over Ref.
* Aluminum	MG/KG	9/ 9		345 - 10900	5670	7800	1		
Antimony	MG/KG	5/ 9	0.23 - 0.43	0.530 - 1.20	0.776	3.1			
* Arsenic	MG/KG	9/ 9		4.00 - 137	47.0	0.37	9		
Barium	MG/KG	9/ 9		10.5 - 70.7	36.6	550			
* Beryllium	MG/KG	2/ 9	0.20 - 0.47	0.450 - 0.650	0.550	0.15	2		
Cadmium	MG/KG	5/ 9	0.030 - 0.070	0.0400 - 0.840	0.418	3.9			
Calcium	MG/KG	9/ 9		274 - 23300	6400				
* Chromium	MG/KG	9/ 9		8.50 - 42.1	22.9	39	1		
Cobalt	MG/KG	9/ 9		1.60 - 11.6	4.16	470			
Copper	MG/KG	9/ 9		7.20 - 75.3	34.3	290			
Iron	MG/KG	9/ 9		5160 - 93700	33500				
Lead	MG/KG	9/ 9		11.2 - 63.6	35.4	400[j]			
Magnesium	MG/KG	9/ 9		39.5 - 2090	946				
* Manganese	MG/KG	8/ 9	0.060 - 0.060	36.9 - 104	71.8	39	7		
Mercury	MG/KG	6/ 9	0.11 - 0.14	0.170 - 1.60	0.592	2.3			
Nickel	MG/KG	9/ 9		3.80 - 26.7	10.7	160			
Potassium	MG/KG	9/ 9		107 - 8240	1660				
Selenium	MG/KG	7/ 9	0.57 - 1.0	0.830 - 9.30	4.95	39			
Sodium	MG/KG	7/ 9	190 - 220	355 - 5860	1820				
* Thallium	MG/KG	6/ 9	0.56 - 1.0	0.670 - 4.60	2.40	0.63	6		
Vanadium	MG/KG	9/ 9		8.10 - 33.5	20.0	55			
Zinc	MG/KG	9/ 9		7.70 - 125	61.5	2300			

Table 10.1.22
Summary of Chemicals Present in Site Samples, SWMU 44
Shallow Groundwater, First Quarter
NAVBASE - Charleston, Zone C
Charleston, South Carolina

NAME	CONC UNITS	FREQ	DETECTS Min	DETECTS Max	DETECTS Avg	SCREENING Value	SCREENING # Over	SCREENING Source	NON-DETECTS Min	NON-DETECTS Max	BACKGROUND Value	BACKGROUND # Over
Dioxins												
Dioxin Equiv.	PG/L	1 - 1	0.5494	0.5494	0.55	0.43	1					
1234678-HpCDD	PG/L	1 - 1	5.384	5.384	5.38							
123789-HxCDF	PG/L	1 - 1	3.29	3.29	3.29							
OCDD	PG/L	1 - 1	163.737	163.737	163.74							
OCDF	PG/L	1 - 1	2.855	2.855	2.86							
Inorganics												
Aluminum (Al)	UG/L	8 - 8	119	38000	6001.75	3700	1	N			410	6
Antimony (Sb)	UG/L	2 - 8	3.3	3.9	3.60	1.5	2	N	1.9	1.9		
Arsenic (As)	UG/L	4 - 8	3.9	15.3	10.78	0.045	4	C	3.2	3.2	6.07	3
Barium (Ba)	UG/L	8 - 8	6.4	60.2	39.38	260		N			16.7	7
Beryllium (Be)	UG/L	1 - 8	21.9	21.9	21.90	0.016	1	C	0.2	0.41	0.33	1
Calcium (Ca)	UG/L	8 - 8	85000	447000	305250.00	NA	8					
Chromium (Cr)	UG/L	8 - 8	1.3	7.1	3.31	18		N			1.99	6
Cobalt (Co)	UG/L	4 - 8	0.96	75.5	34.29	220		N	0.6	0.6	1.33	3
Copper (Cu)	UG/L	7 - 8	2	18.2	7.80	150		N	4	4	1.9	7
Iron (Fe)	UG/L	8 - 8	851	239000	43382.63	1100	7	N				
Lead (Pb)	UG/L	8 - 8	2.2	19.8	7.14	15	1	j			3.27	5
Magnesium (Mg)	UG/L	8 - 8	23200	653000	161025.00	NA	8					
Manganese (Mn)	UG/L	8 - 8	418	1990	1189.38	84	8	N			608	7
Nickel (Ni)	UG/L	8 - 8	2	221	42.24	73	2	N			3.59	4
Potassium (K)	UG/L	8 - 8	7170	282000	81955.00	NA	8					
Selenium (Se)	UG/L	1 - 8	7.2	7.2	7.20	18		N	4.4	4.4		
Sodium (Na)	UG/L	8 - 8	13200	4640000	975875.00	NA	8					
Vanadium (V)	UG/L	5 - 8	6.3	26	11.20	26	1	N	1.3	3.2	1.96	5
Zinc (Zn)	UG/L	8 - 8	18.1	608	191.96	1100		N			13.2	8
Semivolatile Organics												
Acetophenone	UG/L	1 - 2	1	1	1.00	0.0042	1	N	20	20		
Benzoic acid	UG/L	1 - 2	2	2	2.00	15000		N	95	95		
bis(2-Ethylhexyl)phthalate	UG/L	1 - 2	8	8	8.00	4.8	1	C	10	10		

Table 10.1.22
Summary of Chemicals Present in Site Samples, SWMU 44
Shallow Groundwater, First Quarter
NAVBASE - Charleston, Zone C
Charleston, South Carolina

NAME	CONC UNITS	FREQ	DETECTS Min	DETECTS Max	Avg	SCREENING Value	SCREENING # Over	SCREENING Source	NON-DETECTS Min	NON-DETECTS Max	BACKGROUND Value	BACKGROUND # Over

Notes:

* Retained as a chemical of potential concern
C The RBC is based on carcinogenic effects
N The RBC is based on noncarcinogenic effects

Table 10.1.23
SWMU 44 - Coal Storage Area
Surface Water

Parameter	Units	Frequency of Detection	Range of Nondetected Upper Bounds	Range of Detected Concentrations	Average Detected Conc.	Screening[s] Conc.	Num. Over Screen	Reference Conc.	Num. Over Ref.
Acrolein	UG/L	1/ 7	90 - 90	1.00 - 1.00	1.00	73			
* Aluminum	UG/L	10/ 14	19 - 160	175 - 16400	4800	3700	4		
* Antimony	UG/L	5/ 14	1.9 - 1.9	2.40 - 5.20	3.30	1.5	5		
* Arsenic	UG/L	5/ 14	2.7 - 3.2	6.20 - 144	35.4	0.038	5		
Barium	UG/L	14/ 14		1.90 - 75.2	19.7	260			
* Beryllium	UG/L	4/ 14	0.10 - 0.20	1.35 - 5.20	3.29	0.016	4		
Cadmium	UG/L	1/ 14	0.30 - 0.50	0.700 - 0.700	0.700	1.8			
Calcium	UG/L	14/ 14		38400 - 262000	124000				
* Chromium	UG/L	14/ 14		1.60 - 52.4	6.95	18	1		
Cobalt	UG/L	8/ 14	0.50 - 0.60	0.930 - 71.0	23.9	220			
Copper	UG/L	10/ 14	3.0 - 4.4	4.90 - 92.5	22.8	140			
Di-n-butylphthalate	UG/L	3/ 7	15 - 15	1.00 - 2.00	1.33	370			
Dibutyltin	PPB	1/ 4	0.30 - 0.30	0.115 - 0.115	0.115				
Iron	UG/L	14/ 14		359 - 85900	14100				
Lead	UG/L	7/ 14	2.3 - 5.0	3.80 - 9.20	5.44	15[j]			
Magnesium	UG/L	14/ 14		1620 - 373000	154000				
* Manganese	UG/L	14/ 14		18.8 - 2110	403	18	14		
Monobutyltin	PPB	1/ 4	0.30 - 0.30	0.173 - 0.173	0.173				
* Nickel	UG/L	11/ 14	1.4 - 1.4	2.50 - 107	33.6	73	3		
Potassium	UG/L	14/ 14		710 - 197000	79200				
Selenium	UG/L	6/ 14	3.4 - 4.4	4.60 - 10.4	7.57	18			
Sodium	UG/L	14/ 14		3250 - 2910000	1160000				
Vanadium	UG/L	14/ 14		0.620 - 6.90	2.34	26			
Zinc	UG/L	14/ 14		5.30 - 202	61.8	1100			

except nickel and antimony. Because no surface water reference sampling was conducted as part of the SWMU 44 RFI, no formal quantitative risk assessment was attempted relative to surface water.

10.1.10.3 Exposure Assessment

Exposure Setting

The exposure setting at SWMU 44 is the coal storage area. The location, composition, history, and current use of the site are described above in Section 10.1. SWMU 44 is not near any current residential areas. However, the coal storage yard extends northward toward Noisette Creek, and wetlands exist on the west side of the coal pile. The future use of this SWMU is proposed as open buffer space, based on current base reuse plans.

Due to their characteristics, soil and sediment sampled as part of the RFI (except those within the Noisette Creek and associated tidal flats) are essentially the same medium. In most areas, sediment was defined as extremely poorly drained soil areas with some areas of ponded water. The area west and north of the railroad offloading trestles was the primary focus of the soil and sediment sampling effort. A number of samples were also collected from a drainage ditch along the western site border. Exception for three samples collected in Noisette Creek, surface water samples were collected from ditches, pits, and stagnant pools identified across the site.

Potentially Exposed Populations

Potentially exposed populations are current and future site workers. Because many traditional activities at NAVBASE have ceased or are expected to cease in the near future, current site workers were not specifically addressed in the formal assessment. Due to the lack of information regarding the specific functions that will be performed by future site workers, a standard default scenario was developed for these individuals. A similar approach was applied for future site residents. An additional potentially exposed population includes adolescent trespassers who may occasionally enter the area, drawn by the features of the marginal wetland environment.

Exposure Pathways

Exposure pathways for future site workers and site residents were formulated based on an evaluation of the impacted media identified at SWMU 44. Relative to the soil and sediment matrices, incidental ingestion and dermal contact were considered as viable exposure pathways. Ingestion of COPCs identified in shallow groundwater was assessed in this HHRA. No volatile COPCs were identified in the shallow aquifer. As previously discussed, no surface water pathway-specific assessment was performed. Uniform exposure was assumed for all sample locations and media addressed. Table 10.1.24 presents the exposure pathway selection process and justifies each pathway evaluated.

The adolescent trespasser scenario was constructed around the following assumptions. The typical adolescent trespasser was assumed to be between ages 7 and 16, and thus an exposure duration of 10 years was applied. The exposure frequency (within the contaminated portion of the site) was assumed to be 26 days/year, or approximately one day, every other weekend. The exposure frequency was based on the fact that although the poorly drained characteristics of the impacted areas might serve to support some trespasser activities (i.e., wading, fishing, etc.), it would not support more typical adolescent recreational activities (i.e., sports). A body weight of 45 kilograms was used as the mean over the age range. The ingestion rate and skin surface area values were set equal to those of the standard residential adult (100 mg/day and 4,100 square centimeters/event). Due to the nature of the site, it was concluded that few children less than 7 years old would gain access. In addition, individuals in their late teens would be preferentially drawn to activities for which the site is not conducive.

Exposure Point Concentrations

As discussed in Section 7 of this RFI, UCLs are generally calculated for datasets consisting of at least 10 samples. Due to the unique characteristics of SWMU 44, a modified approach was used to establish EPCs for soil and sediment. For shallow groundwater, the maximum detected concentration of each COPC was applied as the EPC, because only eight monitoring wells were sampled. Hexavalent chromium analysis was performed for sample 044HW00401 (shallow groundwater). No hexavalent chromium was detected at a detection limit of 0.01 mg/L. As a result, each chromium detection in SWMU 44 shallow groundwater was considered to be trivalent, and appropriate toxicological values were applied to hazard projections. The maximum concentration of each surface soil or sediment COPC was applied as the EPC to estimate adolescent trespasser exposure.

Table 10.1.24
Exposure Pathways Summary — SWMU 44
NAVBASE — Zone C
Charleston, South Carolina

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Current Land Uses			
Current Site Users/Maintenance	Air, Inhalation of gaseous contaminants emanating from soil	No	Based on the COPCs identified in this HHRA for SWMU 44, no significant VOC concentrations were identified at this site.
	Air, Inhalation of chemicals entrained in fugitive dust	No	Exposure to dust generated by site users traversing the area would be minimized by paved, submerged, and/or vegetated soils.
	Surface Water, Ingestion of contaminants	No	Because no surface water reference sampling was conducted as part of the SWMU 44 RFI, no formal quantitative risk assessment was attempted relative to surface water.

Table 10.1.24
Exposure Pathways Summary — SWMU 44
NAVBASE — Zone C
Charleston, South Carolina

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Current Land Uses			
	Surface Water, Inhalation of volatilized surface water contaminants	No	Because no surface water reference sampling was conducted as part of the SWMU 44 RFI, no formal quantitative risk assessment was attempted relative to surface water.
	Shallow groundwater, Ingestion of contaminants during potable or general use	No	Shallow groundwater is not currently used as a source of potable or nonresidential water at the DMA.
	Shallow groundwater, Inhalation of volatilized shallow groundwater contaminants	No	Shallow groundwater is not currently used as a source of potable or nonresidential water at the DMA.
	Soil, Incidental ingestion	No	No sampling was performed in conjunction with the SWMU 44 investigation for this exposure pathway.
	Soil, Dermal contact	No	No sampling was performed in conjunction with the SWMU 44 investigation for this exposure pathway.
	Sediment, Incidental ingestion	No (Qualified)	Future land use assessment is considered to be protective of current receptors.
	Sediment, Dermal contact	No (Qualified)	Future land use assessment is considered to be protective of current receptors.

Table 10.1.24
Exposure Pathways Summary — SWMU 44
NAVBASE — Zone C
Charleston, South Carolina

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Future Land Uses			
Future Site Residents (Child and Adult) and Future Site Worker	Air, Inhalation of gaseous contaminants emanating from soil	No	Based on the COPCs identified in this HHRA for the DMA, no significant VOC concentrations were identified at this site.
	Air, Inhalation of chemicals entrained in fugitive dust	No	Exposure to dust generated by site users traversing the area would be minimized by paved and/or vegetated soils.
	Surface Water, Ingestion of surface water contaminants	No	Because no surface water reference sampling was conducted as part of the SWMU 44 RFI, no formal quantitative risk assessment was attempted relative to surface water.
	Surface Water, Inhalation of volatilized surface water contaminants	No	Because no surface water reference sampling was conducted as part of the SWMU 44 RFI, no formal quantitative risk assessment was attempted relative to surface water.
	Shallow groundwater, Ingestion of contaminants during potable or general use	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Shallow groundwater, Inhalation of volatilized contaminants during domestic use	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Soil, Incidental ingestion	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Soil, Dermal contact	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.

Table 10.1.24
Exposure Pathways Summary — SWMU 44
NAVBASE — Zone C
Charleston, South Carolina

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Future Land Uses			
	Sediment, Incidental ingestion	Yes	Sediment exposure was assumed to be equivalent to typical soil exposure, and SWMU 44 sediment was formally addressed in this HHRA. COPCs were identified subsequent to risk-based screening comparisons.
	Sediment, Dermal contact	Yes	Sediment exposure was assumed to be equivalent to typical soil exposure, and SWMU 44 sediment was formally addressed in this HHRA. COPCs were identified subsequent to risk-based screening comparisons.
	Wild game or domestic animals, Ingestion of tissue impacted by media contamination	No	Hunting/taking of game and/or raising livestock is prohibited within the Charleston, South Carolina city limits.
	Fruits and vegetables, Ingestion of plant tissues grown in media	No	The potential for significant exposure via this pathway is low relative to that of other exposure pathways assessed.

As discussed earlier, no clear distinction can be made between soil and sediment samples collected from outside Noisette Creek and adjacent tidal flats. As a result, it was assumed that there was equal likelihood of exposure to both media on the upland (nontidal flat) portion of the site. Table 10.1.25 summarizes soil and sediment samples that contained COPCs at concentrations above both the soil reference concentration and the residential soil RBC. This listing was restricted to samples collected in reasonably accessible portions (nontidal flats) of SWMU 44. It

Table 10.1.25
Summary of Sampling Locations Exceeding Residential RBCs
Surface Soil and Sediment
SWMU 44 Zone C
Naval Base Charleston
Charleston, SC

	Area 1				Area 2		Area 3		Area 4	Residential Soil RBC	Reference Concentration
Parameter	044SB00	044SB00	044M015	044M017	044SB00	044M009	044M012	044M013	044M010	(mg/kg)	(mg/kg)
Benzo(a)pyrene equival	*	0.704	*	*	*	*	*	*	*	0.088	NA
Aluminum	17500	<RBC	<RBC	<RBC	<RBC	<RBC	10900	<RBC	<RBC	7800	10017
Arsenic	103	29.8	67.4	69.2	53.6	137	62.1	53.1	<RBC	0.43	24.96
Beryllium	2	0.51	<RBC	<RBC	0.55	0.45	0.65	<RBC	<RBC	0.15	ND
Chromium	<RBC	<RBC	<RBC	<RBC	61.5	37.9	42.1	<RBC	<RBC	39	26.96
Manganese	<RBC	165	<RBC	<RBC	104	104	96.1	<RBC	<RBC	18	94.3
Thallium	2.4	<RBC	4.6	2.7	<RBC	2.4	1.9	2.1	0.67	0.63	ND

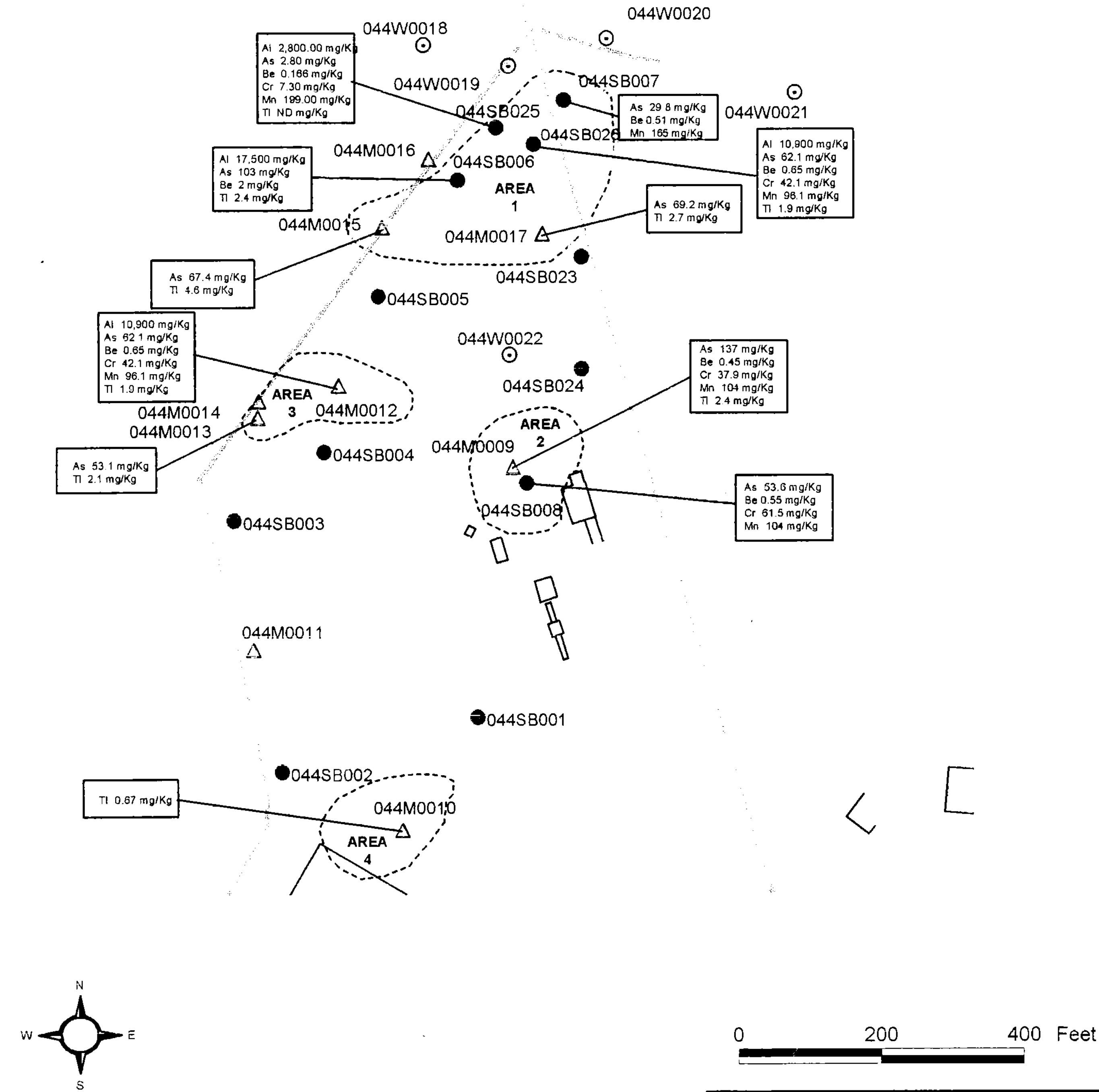
NOTES:
Parameters are denoted as potential concerns based upon comparison to residential soil RBC and/ or reference concentrations.
<RBC indicates that the parameter was detected at a concentration less than the residential RBC or the Zone C background reference concentration.
* Benzo(a)pyrene equivalents were analyzed exclusively in soil sample 044SB007. The BEQ concentration reported at this location was assumed to be representative of all soil and sediment at SWMU 44.
NA indicates not applicable; ND indicates not detected in background samples.

should be noted that BEQ analyses were performed exclusively for sample 044SB007. As a result, the BEQ concentration reported for this sample was considered representative of all soil and sediment across the site. Due to the nature of past operations, cPAHs would be expected as a result of coal pile runoff impacts. Exposure estimates (and resultant risk/hazard projections) based on this single result should be interpreted with discretion.

Figure 10.1.5 shows the reported concentrations of each COPC at impacted soil and sediment sampling locations. A sample location was considered impacted if the concentration of a parameter exceeded both the residential soil RBC and the corresponding reference concentration. From Figure 10.1.5, it is apparent that soil/sediment were not impacted at every location. Instead, spatially segregated areas appeared impacted. Based on an evaluation of the COPCs, the following groups of samples were identified as defining distinct impacted areas. Additional sampling in each of these areas would serve to more precisely define the boundary of each.

Soil sample locations 044SB006 and 044SB007, and sediment locations 044M0015 and 044M0017 broadly define the largest of the areas (approximately 2.5 acres), in the northernmost section of the SWMU (Area 1). The COPCs identified at these locations included arsenic, beryllium, thallium, BEQs, manganese, and aluminum. The maximum soil concentrations of arsenic (103 mg/kg), beryllium (2 mg/kg), aluminum (17,500 mg/kg), manganese (165 mg/kg), and thallium (2.4 mg/kg) were detected in this area. The maximum sediment concentration of thallium (4.6 mg/kg) was reported in sample 044M001501.

The second area was defined by soil sample 044SB008 and sediment sample 044M0009 (Area 2). These samples were collected north of the coal offload trestles immediately adjacent to railroad tracks. Sampling was limited near these impacted locations and, as a result, no estimate of the total areal extent of impacts was made. Based on surface features and expected migration/disposal patterns associated with the source, the results at these locations are not expected to represent



LEGEND

Surface Water Sample
Sediment Sample
Soil Boring
Zone C Boundary
Sidewalk
Railroad
Property Line
Fence
Transformer
Golf Course

NOTE:
Reference concentrations for COPCs were:

Al 10,017 mg/Kg
As 24.96 mg/Kg
Be Not Determined
Cr 26.96 mg/Kg
Mn 94.3 mg/Kg
Tl Non-Detect

ZONE C
FINAL RCRA FACILITY
INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 10.1.5
SWMU 44
SURFACE SOIL AND SEDIMENT
COPC CONCENTRATIONS

DWG DATE: 01/16/96 | DWG NAME: CHARLC.APR surface soil/sediment quality over more than 1 acre. The maximum soil concentration of chromium (61.5 mg/kg) was reported in this area. Sample 044SB00701 was analyzed for hexavalent chromium, which was not detected (detection limit = 0.01 mg/kg). The total chromium concentration was 25.1 mg/kg. Based on these results, all soil chromium was assumed to be trivalent, and appropriate toxicological values were used for hazard projections. The maximum sediment concentrations of arsenic (137 mg/kg) and manganese (104 mg/kg) were reported in this area.

Another area (Area 3), along the drainage features that mark the western SWMU boundary, included sediment sample locations 044M0012 and 044M0013. The area of impacted media was roughly estimated as 0.5 acre, based on the absence of elevated COPC concentrations at surrounding sampling locations. The maximum sediment concentrations of aluminum (10,900 mg/kg), beryllium (0.65 mg/kg), and chromium (42.1 mg/kg) were reported in sample 044M001201.

The final impacted area (Area 4) identified included sediment location 044M0010 only, and is in the extreme southeast corner of the SWMU. Thallium was the only COPC identified at this location with a concentration of 2.4 mg/kg. Sediment sample 044M001001 was collected from the surface water runoff collection point. The area was characterized by poorly drained soil and would serve as a depositional zone for sediment conveyed from the coal offload trestles. The results for sample 044M001001 were estimated to represent roughly one-third of an acre based on topographic features.

In order to provide a more useful presentation of potential risk/hazard at SWMU 44, exposure was estimated based on results specific to each area when computing the future site resident and site worker chronic daily intakes. The COPCs for each area are presented in Table 10.1.25 and the maximum concentration of each was used as the EPC. Due to the extremely limited SVOC analyses performed, the BEQ concentration reported for soil sample 044SB00701 was assumed to be representative of soil and sediment across the entire SWMU. For the adolescent trespasser scenario, the maximum concentration of each soil/sediment COPC was used as the EPC. This method was used assuming that trespassing adolescents would not confine their activities to any specific impacted area. Instead, adolescent trespassers were assumed to have uniform exposure to the entire SWMU.

Quantification of Exposure

Soil/Sediment

Area 1

CDIs for ingestion and dermal contact with SWMU 44 Area 1 surface soil and sediment are shown in Tables 10.1.26 and 10.1.27, respectively.

Area 2

CDIs for ingestion and dermal contact with SWMU 44 Area 2 surface soil and sediment are shown in Tables 10.1.28 and 10.1.29, respectively.

Area 3

CDIs for ingestion and dermal contact with SWMU 44 Area 3 surface soil and sediment are shown in Tables 10.1.30 and 10.1.31, respectively.

Area 4

CDIs for ingestion and dermal contact with SWMU 44 Area 3 surface soil and sediment are shown in Tables 10.1.32 and 10.1.33, respectively.

Table 10.1.26
Chronic Daily Intakes (CDI)
Incidental Ingestion of Surface Soil (0-1')
SWMU 44 (Area 1) Zone C
Naval Base Charleston
Charleston, SC

Chemical	TEF	Fraction Ingested fro Contaminate Source	Exposure Point Concentration (mg/kg)	Potential Future Resident adult H-CDI (mg/kg-day)	Potential Future Resident child H-CDI (mg/kg-day)	Potential Futur Resident lwa C-CDI (mg/kg-day)	Potential Curren Worker adult H-CDI (mg/kg-day)	Potential Current Worker adult C-CDI (mg/kg-day)
Benzo(a)pyrene equival	1	1	0.710	9.72E-07	9.07E-06	1.11E-06	3.47E-07	1.24E-07
Aluminum	NA	1	17500	2.40E-02	2.24E-01	2.74E-02	8.56E-03	3.06E-03
Arsenic	NA	1	103	1.41E-04	1.32E-03	1.61E-04	5.04E-05	1.80E-05
Beryllium	NA	1	2.0	2.74E-06	2.56E-05	3.13E-06	9.78E-07	3.49E-07
Manganese	NA	1	165	2.26E-04	2.11E-03	2.58E-04	8.07E-05	2.88E-05
Thallium	NA	1	4.6	6.30E-06	5.88E-05	7.20E-06	2.25E-06	8.04E-07

NOTES:

TEF	toxic equivalency factor relative to Benzo(a)pyrene
lwa	lifetime weighted average; used to calculate carcinogenic CDI, RAGS Parts A and B
CDI	Chronic Daily Intake in mg/kg-day
H-CDI	CDI for hazard quotient
C-CDI	CDI for excess cancer risk
*	Reflects the estimated fraction of the site impacted by the corresponding COPC.

Table 10.1.27
Chronic Daily Intakes (CDI)
Dermal Contact with Surface Soil (0-1')
SWMU 44 (Area 1) Zone C
Naval Base Charleston
Charleston, SC

Chemical	TEF	Adjusted Exposure Point Concentration (mg/kg)	Fraction Contacted fro Contaminated Source *	Dermal Absorption Factor (unitless)	Potential Future Resident adult H-CDI (mg/kg-day)	Potential Future Resident child H-CDI (mg/kg-day)	Potential Futur Resident lwa C-CDI (mg/kg-day)	Potential Curren Worker adult H-CDI (mg/kg-day)	Potential Current Worker adult C-CDI (mg/kg-day)
Benzo(a)pyrene equival	1	0.710	1	0.01	3.98E-07	1.32E-06	2.49E-07	2.85E-07	1.02E-07
Aluminum	NA	17500	1	0.001	9.83E-04	3.24E-03	6.15E-04	7.02E-04	2.51E-04
Arsenic	NA	103	1	0.001	5.78E-06	1.91E-05	3.62E-06	4.13E-06	1.48E-06
Beryllium	NA	2.0	1	0.001	1.12E-07	3.71E-07	7.03E-08	8.02E-08	2.87E-08
Manganese	NA	165	1	0.001	9.27E-06	3.06E-05	5.80E-06	6.62E-06	2.36E-06
Thallium	NA	4.6	1	0.001	2.58E-07	8.53E-07	1.62E-07	1.85E-07	6.59E-08

NOTES:

TEF Toxic Equivalency Factor relative to Benzo(a)pyrene
CDI Chronic Daily Intake in mg/kg-day
H-CDI CDI for hazard quotient
C-CDI CDI for excess cancer risk
- The dermal absorption factor was applied to the exposure point concentration to reflect the different trans-dermal migration of inorganic versus organic chemicals
* Reflects the estimated fraction of the site impacted by the corresponding COPC.

Table 10.1.28
Chronic Daily Intakes (CDI)
Incidental Ingestion of Surface Soil (0-1')
SWMU 44 (Area 2) Zone C
Naval Base Charleston
Charleston, SC

Chemical	TEF	Fraction Ingested fro Contaminate Source	Exposure Point Concentration (mg/kg)	Potential Future Resident adult H-CDI (mg/kg-day)	Potential Future Resident child H-CDI (mg/kg-day)	Potential Futur Resident lwa C-CDI (mg/kg-day)	Potential Curren Worker adult H-CDI (mg/kg-day)	Potential Current Worker adult C-CDI (mg/kg-day)
Benzo(a)pyrene equival	1	1	0.710	9.72E-07	9.07E-06	1.11E-06	3.47E-07	1.24E-07
Chromium	NA	1	61.5	8.42E-05	7.86E-04	9.63E-05	3.01E-05	1.07E-05
Arsenic	NA	1	137	1.88E-04	1.75E-03	2.14E-04	6.70E-05	2.39E-05
Beryllium	NA	1	0.7	8.90E-07	8.31E-06	1.02E-06	3.18E-07	1.14E-07
Manganese	NA	1	104	1.42E-04	1.33E-03	1.63E-04	5.09E-05	1.82E-05
Thallium	NA	1	2.4	3.29E-06	3.07E-05	3.76E-06	1.17E-06	4.19E-07

NOTES:

TEF	toxic equivalency factor relative to Benzo(a)pyrene
lwa	lifetime weighted average; used to calculate carcinogenic CDI, RAGS Parts A and B
CDI	Chronic Daily Intake in mg/kg-day
H-CDI	CDI for hazard quotient
C-CDI	CDI for excess cancer risk
*	Reflects the estimated fraction of the site impacted by the corresponding COPC.

Table 10.1.29
Chronic Daily Intakes (CDI)
Dermal Contact with Surface Soil (0-1')
SWMU 44 (Area 2) Zone C
Naval Base Charleston
Charleston, SC

Chemical	TEF	Adjusted Exposure Point Concentratio (mg/kg)	Fraction Contacted fro Contaminate Source *	Dermal Absorption Factor (unitless)	Potential Future Resident adult H-CDI (mg/kg-day)	Potential Future Resident child H-CDI (mg/kg-day)	Potential Futur Resident lwa C-CDI (mg/kg-day)	Potential Curren Worker adult H-CDI (mg/kg-day)	Potential Current Worker adult C-CDI (mg/kg-day)
Benzo(a)pyrene equiva	1	0.710	1	0.01	3.98E-07	1.32E-06	2.49E-07	2.85E-07	1.02E-07
Chromium	NA	62	1	0.001	3.45E-06	1.14E-05	2.16E-06	2.47E-06	8.81E-07
Arsenic	NA	137	1	0.001	7.69E-06	2.54E-05	4.82E-06	5.50E-06	1.96E-06
Beryllium	NA	0.7	1	0.001	3.65E-08	1.21E-07	2.28E-08	2.61E-08	9.31E-09
Manganese	NA	104	1	0.001	5.84E-06	1.93E-05	3.66E-06	4.17E-06	1.49E-06
Thallium	NA	2.4	1	0.001	1.35E-07	4.45E-07	8.44E-08	9.63E-08	3.44E-08

NOTES:

TEF Toxic Equivalency Factor relative to Benzo(a)pyrene
CDI Chronic Daily Intake in mg/kg-day
H-CDI CDI for hazard quotient
C-CDI CDI for excess cancer risk
- The dermal absorption factor was applied to the exposure point concentration to reflect the different trans-dermal migration of inorganic versus organic chemicals
* Reflects the estimated fraction of the site impacted by the corresponding COPC.

Table 10.1.30
Chronic Daily Intakes (CDI)
Incidental Ingestion of Surface Soil (0-1')
SWMU 44 (Area 3) Zone C
Naval Base Charleston
Charleston, SC

Chemical	TEF	Fraction Ingested fro Contaminate Source	Exposure Point Concentration (mg/kg)	Potential Future Resident adult H-CDI (mg/kg-day)	Potential Future Resident child H-CDI (mg/kg-day)	Potential Futur Resident lwa C-CDI (mg/kg-day)	Potential Curren Worker adult H-CDI (mg/kg-day)	Potential Current Worker adult C-CDI (mg/kg-day)
Benzo(a)pyrene equival	1	1	0.710	9.72E-07	9.07E-06	1.11E-06	3.47E-07	1.24E-07
Aluminum	NA	1	10900	1.49E-02	1.39E-01	1.71E-02	5.33E-03	1.90E-03
Arsenic	NA	1	62	8.51E-05	7.94E-04	9.72E-05	3.04E-05	1.09E-05
Beryllium	NA	1	0.65	8.90E-07	8.31E-06	1.02E-06	3.18E-07	1.14E-07
Chromium	NA	1	42.1	5.77E-05	5.38E-04	6.59E-05	2.06E-05	7.36E-06
Manganese	NA	1	96	1.32E-04	1.23E-03	1.50E-04	4.70E-05	1.68E-05
Thallium	NA	1	1 9	2.60E-06	2.43E-05	2.97E-06	9.30E-07	3.32E-07

NOTES:

TEF toxic equivalency factor relative to Benzo(a)pyrene
lwa lifetime weighted average; used to calculate carcinogenic CDI, RAGS Parts A and B
CDI Chronic Daily Intake in mg/kg-day
H-CDI CDI for hazard quotient
C-CDI CDI for excess cancer risk
* Reflects the estimated fraction of the site impacted by the corresponding COPC.

Table 10.1.31
Chronic Daily Intakes (CDI)
Dermal Contact with Surface Soil (0-1')
SWMU 44 (Area 3) Zone C
Naval Base Charleston
Charleston, SC

Chemical	TEF	Adjusted Exposure Point Concentratio (mg/kg)	Fraction Contacted fro Contaminate Source *	Dermal Absorption Factor (unitless)	Potential Future Resident adult H-CDI (mg/kg-day)	Potential Future Resident child H-CDI (mg/kg-day)	Potential Futur Resident lwa C-CDI (mg/kg-day)	Potential Curren Worker adult H-CDI (mg/kg-day)	Potential Current Worker adult C-CDI (mg/kg-day)
Benzo(a)pyrene equiva	1	0.710	1	0.01	3.98E-07	1.32E-06	2.49E-07	2.85E-07	1.02E-07
Aluminum	NA	10900	1	0.001	6.12E-04	2.02E-03	3.83E-04	4.37E-04	1.56E-04
Arsenic	NA	62	1	0.001	3.49E-06	1.15E-05	2.18E-06	2.49E-06	8.90E-07
Beryllium	NA	0.65	1	0.001	3.65E-08	1.21E-07	2.28E-08	2.61E-08	9.31E-09
Chromium	NA	42.1	1	0.001	2.36E-06	7.80E-06	1.48E-06	1.69E-06	6.03E-07
Manganese	NA	96	1	0.001	5.40E-06	1.78E-05	3.38E-06	3.86E-06	1.38E-06
Thallium	NA	1.9	1	0.001	1.07E-07	3.52E-07	6.68E-08	7.62E-08	2.72E-08

NOTES:

TEF Toxic Equivalency Factor relative to Benzo(a)pyrene
CDI Chronic Daily Intake in mg/kg-day
H-CDI CDI for hazard quotient
C-CDI CDI for excess cancer risk
- The dermal absorption factor was applied to the exposure point concentration to reflect the different trans-dermal migration of inorganic versus organic chemicals
* Reflects the estimated fraction of the site impacted by the corresponding COPC.

Table 10.1.32
Chronic Daily Intakes (CDI)
Incidental Ingestion of Surface Soil (0-1')
SWMU 44 (Area 4) Zone C
Naval Base Charleston
Charleston, SC

Chemical	TEF	Fraction Ingested fro Contaminate Source	Exposure Point Concentration (mg/kg)	Potential Future Resident adult H-CDI (mg/kg-day)	Potential Future Resident child H-CDI (mg/kg-day)	Potential Futur Resident lwa C-CDI (mg/kg-day)	Potential Curren Worker adult H-CDI (mg/kg-day)	Potential Current Worker adult C-CDI (mg/kg-day)
Benzo(a)pyrene equival	1	1	0.710	9.72E-07	9.07E-06	1.11E-06	3.47E-07	1.24E-07
Thallium	NA	1	0.67	9.18E-07	8.57E-06	1.05E-06	3.28E-07	1.17E-07

NOTES:

TEF	toxic equivalency factor relative to Benzo(a)pyrene
lwa	lifetime weighted average; used to calculate carcinogenic CDI, RAGS Parts A and B
CDI	Chronic Daily Intake in mg/kg-day
H-CDI	CDI for hazard quotient
C-CDI	CDI for excess cancer risk
*	Reflects the estimated fraction of the site impacted by the corresponding COPC.

Table 10.1.33
Chronic Daily Intakes (CDI)
Dermal Contact with Surface Soil (0-1')
SWMU 44 (Area 4) Zone C
Naval Base Charleston
Charleston, SC

Chemical	TEF	Adjusted Exposure Point Concentratio (mg/kg)	Fraction Contacted fro Contaminate Source *	Dermal Absorption Factor (unitless)	Potential Future Resident adult H-CDI (mg/kg-day)	Potential Future Resident child H-CDI (mg/kg-day)	Potential Futur Resident lwa C-CDI (mg/kg-day)	Potential Curren Worker adult H-CDI (mg/kg-day)	Potential Current Worker adult C-CDI (mg/kg-day)
Benzo(a)pyrene equiva	1	0.710	1	0.01	3.98E-07	1.32E-06	2.49E-07	2.85E-07	1.02E-07
Thallium	NA	0.67	1	0.001	3.76E-08	1.24E-07	2.36E-08	2.69E-08	9.60E-09

NOTES:

TEF Toxic Equivalency Factor relative to Benzo(a)pyrene
CDI Chronic Daily Intake in mg/kg-day
H-CDI CDI for hazard quotient
C-CDI CDI for excess cancer risk
- The dermal absorption factor was applied to the exposure point concentration to reflect the different trans-dermal migration of inorganic versus organic chemicals
* Reflects the estimated fraction of the site impacted by the corresponding COPC.

Adolescent Trespassers

CDIs for adolescent trespasser ingestion and dermal contact with SWMU 44 surface soil and sediment are shown in Tables 10.1.34 and 10.1.35, respectively.

Groundwater

CDIs for shallow groundwater ingestion are presented in Table 10.1.36. No volatile COPCs were identified in SWMU 44 shallow groundwater. As a result, the inhalation of volatilized contaminants pathway was not assessed.

10.1.10.4 Toxicity Assessment

Toxicity assessment terms and methods are discussed in Section 7 of this report. Table 10.1.37 summarizes toxicological risk information for the COPCs identified at SWMU 44. The following are brief toxicological profiles for each COPC identified at SWMU 44.

Aluminum is one of the most abundant metals in the earth's crust (7% aluminum), and it is ubiquitous in air and water, as well as soil. This metal is water-soluble, silvery, and ductile, which suggests its usefulness in many processes. Ingesting aluminum can affect the absorption of other elements within the gastrointestinal tract and can alter intestinal function. Aluminum can potentially interfere with the absorption of essential nutrients and cholesterol. Another effect on the gastrointestinal system is the inhibition of acetylcholine-induced contractions, which are part of the neuro-muscular system controlling bowel muscles. The effect could explain why aluminum-containing antacids often produce constipation. Aluminum dust is moderately flammable and explosive in heat. Inhaling this dust can cause fibrosis (aluminosis) (Klaassen, et al., 1986) (Dreisbach, et al., 1987). No data are available on an applicable SF or the USEPA cancer group. The USEPA Region IV Office of Health Assessment suggested using the provisional oral RfD of

Table 10.1.34
Chronic Daily Intakes (CDI)
Incidental Ingestion of Surface Soil/Sediment (0-1')
SWMU 44 Zone C
Naval Base Charleston
Charleston, SC

Chemical	TEF	Adjusted Exposure Point Concentration (mg/kg)	Potential Adolescen Trespasser H-CDI (mg/kg-day)	Potential Adolescent Trespasser C-CDI (mg/kg-day)
Benzo(a)pyrene Equivalent	1	0.710	1.12E-07	1.60E-08
Aluminum	NA	17500	2.77E-03	3.96E-04
Arsenic	NA	137	2.17E-05	3.10E-06
Beryllium	NA	2	3.17E-07	4.52E-08
Chromium	NA	61.5	9.74E-06	1.39E-06
Manganese	NA	165	2.61E-05	3.73E-06
Thallium	NA	4.6	7.28E-07	1.04E-07

NOTES:

TEF toxic equivalency factor relative to Benzo(a)pyrene
CDI Chronic Daily Intake in mg/kg-day
H-CDI CDI for hazard quotient
C-CDI CDI for excess cancer risk
- exposure point concentrations for PAHs were adjusted to equivalent concentrations of Benzo(a)pyrene by their corresponding TEF.

Table 10.1.35
Chronic Daily Intakes (CDI)
Dermal Contact with Surface Soil/Sediment (0-1')
SWMU 44 Zone C
Naval Base Charleston
Charleston, SC

Chemical	TEF	Adjusted Exposure Point Concentration (mg/kg)	Dermal Absorption Factor (unitless)	Potential Adolescent Trespasser H-CDI (mg/kg-day)	Potential Adolescent Trespasser C-CDI (mg/kg-day)
Benzo(a)pyrene Equivalent	1	0.70958	0.01	4.61E-08	6.58E-09
Aluminum	NA	17500	0.01	1.14E-03	1.62E-04
Arsenic	NA	137	0.01	8.89E-06	1.27E-06
Beryllium	NA	2	0.01	1.30E-07	1.85E-08
Chromium	NA	61.5	0.001	3.99E-07	5.70E-08
Manganese	NA	165	0.001	1.07E-06	1.53E-07
Thallium	NA	4.6	0.001	2.99E-08	4.26E-09

NOTES:

TEF Toxic Equivalency Factor relative to benzo(a)pyrene
CDI Chronic Daily Intake in mg/kg-day
H-CDI CDI for hazard quotient
C-CDI CDI for excess cancer risk
- The dermal absorption factor was applied to the exposure point concentration to reflect the different trans-dermal migration of inorganic versus organic chemicals
- exposure point concentrations for PAHs were adjusted to equivalent concentrations of Benzo(a)pyrene by their corresponding TEF.

Table 10.1.36
Chronic Daily Intakes (CDI)
Ingestion of COPCs in Shallow Groundwater
SWMU 44 Zone C
Naval Base Charleston
Charleston, SC

Chemical	Adjusted Exposure Point Concentration (mg/liter)	Potential Future Resident adult H-CDI (mg/kg-day)	Potential Future Resident child H-CDI (mg/kg-day)	Potential Futur Resident lwa C-CDI (mg/kg-day)	Potential Future Worker adult H-CDI (mg/kg-day)	Potential Future Worker adult C-CDI (mg/kg-day)
Aluminum	38	1.04E+00	2.43E+00	5.73E-01	3.72E-01	1.83E-01
Antimony	0.0039	1.07E-04	2.49E-04	5.88E-05	3.82E-05	1.88E-05
Arsenic	0.015	4.19E-04	9.78E-04	2.31E-04	1.50E-04	7.36E-05
Beryllium	0.022	6.00E-04	1.40E-03	3.30E-04	2.14E-04	1.05E-04
Bis(2-Ethylhexyl)phth	0.008	2.19E-04	5.11E-04	1.21E-04	7.83E-05	3.85E-05
Lead	0.020	5.42E-04	1.27E-03	2.98E-04	1.94E-04	9.53E-05
Manganese	1.99	5.45E-02	1.27E-01	3.00E-02	1.95E-02	9.58E-03
Nickel	0.221	6.05E-03	1.41E-02	3.33E-03	2.16E-03	1.06E-03
2,3,7,8-TCDD equival	5.4E-10	1.48E-11	3.45E-11	8.14E-12	5.28E-12	2.60E-12
Acetophenone	0.001	2.74E-05	6.39E-05	1.51E-05	9.78E-06	4.81E-06

NOTES:

lwa lifetime weighted average
CDI Chronic Daily Intake
H-CDI Non-carcinogenic hazard based Chronic Daily Intake
C-CDI Carcinogenic risk based Chronic Daily Intake

Table 10.1.37
Toxicological Database Informa ion
for Chemicals of Potential Conc rn
SWMU 44
NAVBASE Charleston, Zone C

Non-Carcinogenic Toxicity Data

Chemical	Oral Reference Dose (mg/kg/day)		Confidence Level	Critical Effect	Uncertainty Factor Oral	Inhalation Reference Dose (mg/kg/day)		Confidence Level	Critical Effect	Uncertainty Factor Inhalation
Aluminum	1	e			ND	ND				ND
Antimony	0.0004	a	L	whole body/blood increased mortality	1000	ND				ND
Arsenic	0.0003	a	M	hyperpigmentation	3	ND				ND
Benzo(a)pyrene Equivalents	ND				ND	ND				ND
Beryllium	0.005	a	L	microscopic organ changes	100	ND				ND
bis(2-Ethylhexyl)phthalate	0.02	a	M	increased liver weight	1000	ND				ND
Chromium	1	a	L	NA	100/10	ND				ND
Lead	ND				ND	ND				ND
Manganese (food)	0.14	a	NA	neurological effects	1	ND				ND
Manganese (water)	0.005	a	NA	neurological effects	1	1.43E-05	a	M	neurological effects	1000
Nickel	0.02	a	M	decreased body and organ weight	300	ND				ND
Thallium	8E-05	a		increased SGOT (liver) increased seru	3000	ND				ND

NOTES:

a Integrated Risk Information System (IRIS)
b Health Effects Assessment Summary Tables (HEAST)
c HEAST alternative method
d USEPA Region III Screening Tables
e EPA Environmental Criteria and Assessment Office - Cincinnati (provisional)
f Withdrawn from IRIS or HEAST
NA Not applicable or not available
ND Not determined due to lack of information

Table 10.1.37
Toxicological Database Informa
for Chemicals of Potential Conc
SWMU 44
NAVBASE Charleston, Zone C

Carcinogenic Toxicity Data

Chemical	Oral Slope Factor [(mg/kg/day)]-1		Inhalation Slope Factor [(mg/kg/day)]-1		Weight of Evidence	Tumor Type
Aluminum	ND		ND		ND	
Antimony	ND		ND		D	
Arsenic	1.5	a	15.1	a	A	various
Benzo(a)pyrene Equivalents	7.3	a			B2	mutagen
Beryllium	4.3	a	8.4	a	B2	osteosarcoma
bis(2-Ethylhexyl)phthalate	0.014	a	ND		B2	hepatoma
Chromium	ND		42	a	D	
Lead	ND		ND		B2	various
Manganese (food)	ND		ND		D	
Manganese (water)	ND		ND		D	
Nickel	ND		ND		D	
Thallium	ND		ND		D	

1.0 mg/kg-day. The aesthetic-based SMCL for drinking water is 50 to 200 μg/L (USEPA, Office of Water).

Arsenic exposure via the ingestion route causes darkening and hardening of the skin in chronically exposed humans. Inhalation exposure to arsenic causes neurological deficits, anemia, and cardiovascular effects (Klaassen, et al., 1986). USEPA set 0.3 μg/kg-day as the RfD for arsenic based on a NOAEL of 0.8 μg/kg-day in a human exposure study. Arsenic's effects on the nervous and cardiovascular systems are primarily associated with acute exposure to higher levels. Exposure to arsenic-containing materials has been shown to cause cancer in humans. Inhalation of these materials can lead to increased lung cancer risk, and ingestion of these materials is associated with increased skin cancer rates. Arsenic has been classified as a group A carcinogen by USEPA, which set the 1.5 $(\text{mg/kg-day})^{-1}$ SF for arsenic. As listed in IRIS (search date September 1, 1995), the basis for the classification is sufficient evidence from human data. An increased lung cancer mortality was observed in multiple human populations exposed primarily through inhalation. Also, increased mortality from multiple internal organ cancers (liver, kidney, lung, and bladder) and an increased incidence of skin cancer were observed in populations consuming drinking water high in inorganic arsenic. Human milk contains about 3 μg/L arsenic (Klaassen, et al., 1986). The RBC for arsenic in tap water is 0.038 μg/L. As listed in IRIS (search date September 1, 1995), the critical effect of this chemical is hyperpigmentation, keratosis, and possible vascular complications. The uncertainty factor was determined to be 3 and the modifying factor was determined to be 1.

Chromium exists in two stable, natural forms: trivalent (CrIII), and hexavalent (CrVI). Acute exposure to chromium can result in kidney damage following oral exposure or damage to the nasal mucosa and septum following inhalation exposure. Chronic inhalation exposure to hexavalent chromium has resulted in kidney and respiratory tract damage, as well as excess lung cancer in both animals and humans following occupational exposure. Only hexavalent chromium is believed to be carcinogenic by inhalation (Gradient, 1991). Oral RfD values for both forms of chromium are 1.0 and 5E-3 (mg/kg-day). For trivalent chromium, the RfD is based on liver toxicity in the rat. For the hexavalent form, the RfD is based on unspecified pathological changes observed in rat studies. In addition, hexavalent chromium is considered a group A carcinogen for inhalation exposures, and a SFo of 42 $(mg/kg\text{-}day)^{-1}$ has been established for the hexavalent form. Vitamin supplements contain approximately 0.025 mg of chromium. As listed in IRIS (search date June 28, 1995), no critical effects were observed for chromium (III). The uncertainty factor was determined to be 100 and the modifying factor was determined to be 10. IRIS lists (search date June 28, 1995), no critical effects were observed for chromium (VI). The uncertainty factor was determined to be 500 and the modifying factor was determined to be 1.

Manganese is an essential nutrient, but chronic exposure (0.8 mg/kg-day) causes mental disturbances. Studies have shown that manganese uptake from water is greater than manganese uptake from food, and the elderly appear to be more sensitive than children (Klaassen, et al.,1986) (Dreisbach, et al., 1987). Because of the different uptake rates in water and food, USEPA set two oral RfDs – one for water and one for food. These RfDs are 0.005 and 0.14 mg/kg-day. Inhalation of manganese dust causes neurological effects and increased incidence of pneumonia. An inhalation RfD was set to 0.0000143 mg/kg-day. According to USEPA, manganese can not be classified as to its carcinogenicity. Therefore, the cancer class for manganese is group D. As listed in IRIS (search date June 29, 1995), the basis for the classification is existing studies that are inadequate to assess the carcinogenicity of manganese. Manganese is an element considered essential to human health. The typical vitamin supplement dose of manganese is 2.5 mg/day. As listed in IRIS (search date June 29, 1995), the critical effects of this chemical in water in the oral summary are CNS effects. The uncertainty factor was determined to be 1 and the modifying factor was determined to be 1. The critical effects of this chemical in food in the oral summary are CNS effects. The uncertainty factor was 1 and the modifying factor was 1. As listed in IRIS (search date June 29, 1995), the critical affect of this chemical in the inhalation summary is impairment of neuro-behavioral function. The uncertainty factor was 1000 and the modifying factor was 1. The IRIS RfC is 0.00005 mg/m^3.

Polyaromatic Hydrocarbons or BaP equivalents include the following list of COPCs:

Benzo(a)anthracene	TEF	0.1
Benzo(b)fluoranthene	TEF	0.1
Dibenz(a,h)anthracene	TEF	1.0
Benzo(k)fluoranthene	TEF	0.01
Benzo(a)pyrene	TEF	1.0
Indeno(1,2,3-cd)pyrene	TEF	0.1
Chrysene	TEF	0.001

Some PAHs are toxic to the liver, kidney, and blood. However, the toxic effects of the PAHs above have not been well established. There are no RfDs for the PAHs above due to a lack of data. All PAHs listed above are classified by USEPA as B2 carcinogens, and their carcinogenicity is addressed relative to that of BaP, having an oral SF 7.3 (mg/kg-day)$^{-1}$. Toxicity Equivalency Factors, also set by USEPA, are multipliers that are applied to the detected concentrations, which are subsequently used to calculate excess cancer risk. These multipliers are discussed further in the exposure and toxicity assessment sections. Most carcinogenic PAHs have been classified as such due to animal studies using large doses of purified PAHs. There is some doubt as to the validity of these listings, and the SFs listed in USEPA's RBC table are provisional. However, these PAHs are carcinogens when the exposure involves a mixture of other carcinogenic substances (e.g., coal tar, soot, cigarette smoke, etc.). As listed in IRIS (search data June 28, 1995), the basis for the BaP B2 classification is human data specifically linking BaP to a carcinogenic effect are lacking. There are, however, multiple animal studies in many species demonstrating BaP to be carcinogenic by numerous routes.

BaP has produced positive results in numerous genotoxicity assays. At the June 1992 CRAVE Work Group meeting, a revised risk estimate for BaP was verified (see Additional Comments for Oral Exposure). This section provides information on three aspects of the carcinogenic risk assessment for the agent in question: the USEPA classification and quantitative estimates of exposure. The classification reflects a weight-of-evidence judgment of the likelihood that the agent is a human carcinogen. The quantitative risk estimates are presented in application of a low-dose extrapolation procedure and presented as the risk per (mg/kg)/day. The unit risk is the quantitative estimate in terms of either risk per μg/L drinking water or risk per $\mu g/m^3$ air breathed. The third form in which risk is presented is drinking water or air concentration providing cancer risks of 1 in 10,000 or 1 in 1,000,000. The Carcinogenicity Background Document provides details on the carcinogenicity values found in IRIS. Users are referred to the Oral Reference Dose and Reference Concentration sections for information on long-term toxic effects other than carcinogenicity.

As listed in IRIS (search date June 28, 1995), the basis for the dibenz(a,h)anthracene and benzo(b)fluoranthene B2 classification is no human data and sufficient data from animal bioassays. Benzo(b)fluoranthene produced tumors in mice after lung implantation, intraperitoneal or subcutaneous injection, and skin painting. As listed in IRIS (search date June 28, 1995), the basis for the benzo(a)anthracene B2 classification is no human data and sufficient data from animal bioassays. Benzo(a)anthracene produced tumors in mice exposed by gavage; intraperitoneal, subcutaneous or intramuscular injection; and topical application. Benzo(a)anthracene produced mutations in bacteria and in mammalian cells, and transformed mammalian cells in culture. As listed in IRIS (search date June 28, 1995) the basis for the benzo(k)fluoranthene B2 classification is no human data and sufficient data from animal bioassays. Benzo(k)fluoranthene produced tumors after lung implantation in mice and when administered with a promoting agent in skin-painting studies. Equivocal results have been found in a lung adenoma assay in mice. Benzo(k)fluoranthene is mutagenic in bacteria (Klaassen, et al., 1986).

Other PAHs — those not classified by USEPA as carcinogens — are toxic to the liver, kidney and blood. This group of PAHs includes compounds such as *pyrene*, *acenaphthene, acenaphthylene*, *benzo(g,h,i)perylene*, and *phenanthrene*. USEPA determined RfDs for only two of these compounds: pyrene's RfDo of 0.03 mg/kg-day is also used as a surrogate RfDo for phenanthrene. The RfDo for acenaphthene was 0.06 mg/kg-day.

Lead has been classified as a group B2 carcinogen by USEPA based on animal data. No RfD or SF has been set by USEPA. However, an action level for soil protective of child residents has been proposed by USEPA Region IV, 400 mg/kg. USEPA's OSWER has recommended a 1,000 mg/kg cleanup standard for industrial properties. USEPA's Office of Water has established a treatment technique action level of 15 μg/L. As listed in IRIS (search date October 17, 1995), the basis for classification is sufficient animal evidence. Ten rat bioassays and one mouse assay have shown statistically significant increases in renal tumors with dietary and subcutaneous exposure to several soluble lead salts. Animal assays provide reproducible results in several laboratories, in multiple rat strains with some evidence of multiple tumor sites. Short-term studies show that lead affects gene expression. Human evidence is inadequate. An RfD and SF have not been set because of the confounding nature of lead toxicity. Lead can accumulate in bone marrow, and effects have been observed in the CNS, blood, and mental development of children. RfDs are based on the assumption that a threshold must be exceeded to result in toxic effects (other than carcinogenicity). Once lead accumulates in the body, other influences cause the actual levels in the blood to fluctuate – sometimes the lead is attached to binding sites; sometimes lead is free flowing. If an exposed individual has previously been exposed to lead, this individual could lose weight and set fat-bound lead free. This fluctuation and lack of previous lead exposure data are two of the reasons lead effects are difficult to predict (Klaassen, et al., 1986).

Antimony belongs to the same periodic group as arsenic. This element is absorbed slowly through the gastrointestinal tract. Another target is the blood, where antimony concentrates. Due to frequent industrial use, the primary exposure route for antimony to the general population is food. Antimony is also a common air pollutant from industrial emissions (Klaassen, et al., 1986). USEPA has not classified antimony as a carcinogen, and the RfDo is 0.0004 mg/kg-day. As listed in IRIS (search date June 28, 1995), the critical effect of this chemical is longevity, blood glucose, and cholesterol. The uncertainty factor was 1000 and the modifying factor was 1.

Beryllium exposure via the inhalation route can cause inflammation of the lungs, a condition known as Acute Beryllium Disease, as a result of short-term exposure to high concentrations. Removal from exposure results in a reversal of the symptoms. Chronic exposure to much lower levels of beryllium or beryllium oxide by inhalation has been reported to cause chronic beryllium disease, with symptoms including shortness of breath, scarring of the lungs, and berylliosis, which is noncancerous growths in the lungs of humans. Both forms of beryllium disease can be fatal, depending on the severity of the exposure. Additionally, a skin allergy may develop when soluble beryllium compounds come into contact with the skin of sensitized individuals (Gradient, 1991). An oral RfD of 0.0054 mg/kg-day has been set for beryllium based on a chronic oral bioassay (rats were the study species) which determined no adverse effect occurs at 0.54 mg/kg-day. Beryllium has been classified by USEPA as a group B2 carcinogen based on animal studies. It has been shown to induce lung cancer via inhalation in rats and monkeys, and to induce osteosarcomas in rabbits via intravenous or intramedullary injection. Human epidemiology studies of beryllium are considered to be inadequate. As listed in IRIS (search date June 28, 1995), the basis for the classification is that beryllium has been shown to induce lung cancer via inhalation in rats and monkeys and to induce osteosarcomas in rabbits via intravenous or intramedullary injection. Human epidemiology studies are considered inadequate. An inhalation slope factor of 8.4 (mg/kg-day)$^{-1}$ and an oral SF of 4.3 (mg/kg-day)$^{-1}$ have been set by USEPA. As listed in IRIS (search date June 28, 1995), the critical effect of this chemical is no adverse effect. The uncertainty factor was 100 and the modifying factor was 1. The IRIS RfD in drinking water is 0.005 mg/kg-day.

Nickel is also an essential nutrient with a five microgram dose typical of supplemental vitamins. USEPA set the RfDo to 0.02 mg/kg-day. Chronic exposure of rats to nickel caused decreased body and organ weights. For a chronically exposed individual, nickel salts would affect the gastrointestinal system, and would also target the liver and kidney. This element has been shown to be a sensitizer, an element that can produce allergic reactions. Sensitization of skin to nickel dust has been shown to occur in industry (Dreisbach, et al., 1987). As listed in IRIS (search date June 28, 1995), the critical effect of this chemical is decreased body and organ weights. The uncertainty factor was 300 and the modifying factor was 1.

Thallium is readily absorbed through the gut and skin. Primary effects are stomach and bowel disturbances, kidney and liver damage, and neurological disturbances. Thallium was used in the past as a rodenticide and ant killer, and its use for these purposes is now prohibited. This element remains in the body for a relatively long time, and could accumulate if the chronic dose is large (Klaassen, et al., 1986; Dreisbach, et al., 1987). USEPA's RfDo for thallium is 0.00008 mg/kg-day.

bis(2-ethylhexyl)phthalate, otherwise known as BEHP or DEHP, is a plasticizer used in virtually every major product category. Phthalate esters are ubiquitously distributed in the environment. Although the toxicity of this compound is relatively low, it is a carcinogen. Reproductive effects are also possible (indicated in animal studies) due to chronic exposure to BEHP (Klaassen, et al.,1986). As listed in IRIS (search date October 17, 1995), the basis for the classification is orally administered BEHP produced significant dose-related increase in liver tumor responses in rats and mice of both sexes. This compound is classified as a B2 carcinogen, and USEPA set the RfDo and SFo to 0.02 mg/kg-day and 0.014 $(mg/kg\text{-}day)^{-1}$, respectively. As listed in IRIS (search date October 17, 1995), the critical effect of this chemical is increased relative liver weight. The uncertainty factor was determined to be 1000 and the modifying factor was determined to be 1.

10.1.10.5 Risk Characterization

Surface Soil/Sediment Pathways

Exposure to surface soil was evaluated under residential and industrial (site worker) scenarios. In addition, potential adolescent trespasser exposure was assessed. For each scenario, the incidental ingestion and dermal contact exposure pathways were evaluated. For noncarcinogenic contaminants, evaluated for future site residents, hazard was computed separately to address child and adult exposure. With respect to surface soil and sediment pathways, each impacted area previously discussed is addressed separately, as noted in the corresponding tables and discussions. The nature and extent of COCs identified in each area is discussed immediately following the soil risk characterization for each. These discussions focus on sampling locations where concentrations exceeding residential RBCs and reference concentrations were reported.

Area 1

Tables 10.1.38 and 10.1.39 present the computed carcinogenic risks and/or HQs associated with the incidental ingestion of, and dermal contact with, Area 1 surface soil and sediment.

Hypothetical Site Residents

The ingestion ILCR (based on the adult and child lifetime weighted average) is 3E-4. The dermal pathway ILCR is 3E-5. Arsenic, BaP (as BEQ), and beryllium are the primary contributors for both pathways.

The computed hazard index for the adult resident is 0.6 for the soil ingestion pathway. The computed hazard index for the child ingestion pathway is 5, with aluminum (HQ=0.2), arsenic (HQ=4.4), and thallium (HQ=0.7) as the primary contributors. The dermal contact pathway hazard indices are 0.1 and 0.4 for adult and child receptors, respectively. Arsenic is the primary contributor to dermal pathway hazard.

Table 10.1.38
Hazard Quotients and Incremental Lifetime Cancer Risks
Incidental Surface Soil Ingestion
SWMU 44 (Area 1) Zone C
Naval Base Charleston
Charleston, SC

Chemical	Oral RfD Used (mg/kg-day)	Oral SF Used (mg/kg-day)-1	Potential Future Resident adult Hazard Quotient	Potential Future Resident child Hazard Quotient	Potential Futur Resident lwa ILCR	Potential Curren Worker adult Hazard Quotient	Potential Current Worker adult ILCR
Benzo(a)pyrene equivale	NA	7.3	ND	ND	8.1E-06	ND	9.0E-07
Aluminum	1	NA	0.024	0.22	ND	0.0086	ND
Arsenic	0.0003	1.5	0.47	4.39	2.4E-04	0.17	2.7E-05
Beryllium	0.005	4.3	0.0005	0.005	1.3E-05	0.00020	1.5E-06
Manganese	0.047	NA	0.0048	0.045	ND	0.00172	ND
Thallium	8E-05	NA	0.079	0.74	ND	0.028	ND
SUM Hazard Index/ILCR			0.6	5	3E-04	0.2	3E-05

NOTES:

NA Not available
ND Not Determined due to lack of available information
lwa lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime excess Cancer Risk

Table 10.1.39
Hazard Quotients and Incremental Lifetime Cancer Risks
Dermal Contact With Surface Soil
SWMU 44 (Area 1) Zone C
Naval Base Charleston
Charleston, SC

Chemical	Dermal Adjustment	Oral RfD Used (mg/kg-day	Oral SF Used (mg/kg-day)-1	Potential Future Resident adult Hazard Quotient	Potential Future Resident child Hazard Quotient	Potential Futu Resident lwa ILCR	Potential Curren Worker adult Hazard Quotient	Potential Current Worker adult ILCR
Benzo(a)pyrene equiva	0.5	NA	14.6	ND	ND	3.6E-06	ND	1.5E-06
Aluminum	0.2	0.2	NA	0.005	0.02	ND	0.004	ND
Arsenic	0.2	6E-05	7.5	0.10	0.32	2.7E-05	0.07	1.1E-05
Beryllium	0.2	0.001	21.5	0.0001	0.0004	1.5E-06	0.0001	6.2E-07
Manganese	0.2	0.0094	NA	0.0010	0.003	ND	0.0007	ND
Thallium	0.2	1.6E-05	NA	0.016	0.053	ND	0.012	ND
SUM Hazard Index/ILCR				0.1	0.4	3E-05	0.08	1E-05

NOTES:

NA Not available
ND Not Determined due to lack of available information
lwa lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime excess Cancer Risk
- Dermal to absorbed dose adjustment factor is applied to adjust for Oral SF and RfD (i.e., the oral RfD is based on oral absorption efficiency which should not be applied to dermal exposure and dermal CDI)

COCs identified for this scenario based on their contribution to risk/hazard are aluminum, arsenic, BEQs, beryllium, and thallium.

Hypothetical Site Workers

Site worker ILCRs are 3E-5 and 1E-5 for the ingestion and dermal contact pathways, respectively. Arsenic and beryllium are the primary contributors along with BEQs. The hazard indices for the ingestion and dermal hypothetical site worker are both projected to be 0.2 and 0.08, respectively. Arsenic is the only significant contributor for both pathways.

COCs identified for this scenario based on their contribution to risk/hazard are arsenic, beryllium, and BEQs.

Nature and Extent of Surface Soil/Sediment COCs – Area 1

Aluminum, arsenic, beryllium, thallium and BEQs were identified as COCs in SWMU 44 Area 1. Aluminum was detected in only one sample (044SB00601) at a concentration exceeding the background concentration. As a result, chronic exposure to elevated aluminum concentrations is unlikely. In fact, all other surface soil and sediment samples collected in this area had aluminum concentrations below the residential RBC. Arsenic concentrations are elevated in surface soil and sediment throughout Area 1. Beryllium was detected in both surface soil samples collected in this area, but was not detected in sediment. Although the reported beryllium concentrations are above the residential RBC, the maximum concentration (2.0 mg/kg; 044SB00601) does not differ appreciably from background concentrations reported in other zones (Zone H — 1.46 mg/kg, Zone I — 3.17 mg/kg). Thallium was detected in three of four surface soil and sediment samples collected in this area. No thallium detections were reported in Zone C background surface soil samples, indicating that the concentrations reported in SWMU 44 Area 1 may be related to past or current site operations.

Area 2

Tables 10.1.40 and 10.1.41 present the computed carcinogenic risks and/or HQs associated with the incidental ingestion of and dermal contact with Area 2 surface soil and sediment.

Hypothetical Site Residents

The ingestion ILCR (based on the adult and child lifetime weighted average) is 3E-4. The dermal pathway ILCR is 4E-5. Arsenic, BEQs, and beryllium are the primary contributors for the ingestion pathway. Arsenic and BEQs are the primary contributors for the dermal pathway.

The computed hazard index for the adult resident is 0.7 for the soil ingestion pathway. The computed hazard index for the child ingestion pathway is 6, with arsenic (HQ=5.8) as the primary contributor. The dermal contact pathway hazard indices are 0.1 for the adult resident and 0.4 for the child resident. Arsenic is the only significant contributor to the dermal pathway hazard.

COCs identified for this scenario based on their contribution to risk/hazard are arsenic, BEQs, beryllium, and thallium.

Hypothetical Site Workers

Site worker ILCRs are 4E-5 and 2E-5 for the ingestion and dermal contact pathways, respectively. Arsenic and BEQs are the only contributors for both pathways. The hazard indices for the ingestion and dermal hypothetical site worker are both projected to be less than 0.3.

COCs identified for this scenario based on their contribution to risk/hazard are: arsenic and BEQs.

Table 10.1.40
Hazard Quotients and Incremental Lifetime Cancer Risks
Incidental Surface Soil Ingestion
SWMU 44 (Area 2) Zone C
Naval Base Charleston
Charleston, SC

Chemical	Oral RfD Used (mg/kg-day)	Oral SF Used (mg/kg-day)-1	Potential Future Resident adult Hazard Quotient	Potential Future Resident child Hazard Quotient	Potential Futur Resident lwa ILCR	Potential Curren Worker adult Hazard Quotient	Potential Current Worker adult ILCR
Benzo(a)pyrene equiva	NA	7.3	ND	ND	8.1E-06	ND	9.0E-07
Chromium	1	NA	0.0001	0.0008	ND	0.00003	ND
Arsenic	0.0003	1.5	0.63	5.84	3.2E-04	0.22	3.6E-05
Beryllium	0.005	4.3	0.0002	0.002	4.4E-06	0.00006	4.9E-07
Manganese	0.047	NA	0.0030	0.028	ND	0.00108	ND
Thallium	8E-05	NA	0.041	0.38	ND	0.015	ND
SUM Hazard Index/ILCR			0.7	6	3E-04	0.2	4E-05

NOTES:

NA Not available
ND Not Determined due to lack of available information
lwa lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime excess Cancer Risk

Table 10.1.41
Hazard Quotients and Incremental Lifetime Cancer Risks
Dermal Contact With Surface Soil
SWMU 44 (Area 2) Zone C
Naval Base Charleston
Charleston, SC

Chemical	Dermal Adjustment	Oral RfD Used (mg/kg-day	Oral SF Used (mg/kg-day)-1	Potential Future Resident adult Hazard Quotient	Potential Future Resident child Hazard Quotient	Potential Futu Resident lwa ILCR	Potential Curren Worker adult Hazard Quotient	Potential Current Worker adult ILCR
Benzo(a)pyrene equiva	0.5	NA	14.6	ND	ND	3.6E-06	ND	1.5E-06
Chromium	0.2	0.2	NA	0.00002	0.0001	ND	0.00001	ND
Arsenic	0.2	6E-05	7.5	0.13	0.42	3.6E-05	0.09	1.5E-05
Beryllium	0.2	0.001	21.5	0.0000	0.0001	4.9E-07	0.0000	2.0E-07
Manganese	0.2	0.0094	NA	0.0006	0.002	ND	0.0004	ND
Thallium	0.2	1.6E-05	NA	0.008	0.028	ND	0.006	ND
SUM Hazard Index/ILCR				0.1	0.5	4E-05	0.10	2E-05

NOTES:

NA Not available
ND Not Determined due to lack of available information
lwa lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime excess Cancer Risk
- Dermal to absorbed dose adjustment factor is applied to adjust for Oral SF and RfD (i.e., the oral RfD is based on oral absorption efficiency which should not be applied to dermal exposure and dermal CDI)

Nature and Extent of Surface Soil/Sediment COCs – Area 2

Arsenic, beryllium, chromium, thallium, and BEQs were identified as COCs in SWMU 44 Area 2. Arsenic concentrations were elevated in each surface soil and sediment sample collected in Area 2. Beryllium was detected in each sample collected in this area. Although the reported beryllium concentrations are above the residential RBC, the maximum concentration (0.55 mg/kg; 044SB00801) is below background levels reported in other zones (Zone H — 1.46 mg/kg, Zone I — 3.17 mg/kg). Thallium was detected only in sample 044M00901 at a concentration of 2.4 mg/kg. The fact that no thallium detections were reported in Zone C background surface soil samples indicates that the concentrations reported in SWMU 44 Area 2 may be related to past or current site operations. As mentioned in *Exposure Point Concentrations*, SVOCs were analyzed on an extremely limited basis for SWMU 44 surface soil and sediment. The BEQ concentration used for ILCR projections in Area 2 was derived from the results for sample 044SB00701 collected in Area 1. Very little confidence can be placed in resultant ILCR projections for Area 2. These projections should be viewed as qualitative information indicating that surface soil and/or sediment BEQ concentrations in each area of SWMU 44 could pose an unacceptable risk.

Area 3

Tables 10.1.42 and 10.1.43 present the computed carcinogenic risks and/or HQs associated with the incidental ingestion of and dermal contact with Area 3 surface soil and sediment.

Hypothetical Site Residents

The ingestion ILCR (based on the adult and child lifetime weighted average) is 2E-4. The dermal pathway ILCR is 2E-5. Arsenic, beryllium and BEQs were the primary contributors for the ingestion pathway. Arsenic and BEQs were the primary contributors for the dermal pathway.

Table 10.1.42
Hazard Quotients and Incremental Lifetime Cancer Risks
Incidental Surface Soil Ingestion
SWMU 44 (Area 3) Zone C
Naval Base Charleston
Charleston, SC

Chemical	Oral RfD Used (mg/kg-day)	Oral SF Used (mg/kg-day)-1	Potential Future Resident adult Hazard Quotient	Potential Future Resident child Hazard Quotient	Potential Futur Resident lwa ILCR	Potential Curren Worker adult Hazard Quotient	Potential Current Worker adult ILCR
Benzo(a)pyrene equivale	NA	7.3	ND	ND	8.1E-06	ND	9.0E-07
Aluminum	1	NA	0.015	0.14	ND	0.0053	ND
Arsenic	0.0003	1.5	0.28	2.65	1.5E-04	0.10	1.6E-05
Beryllium	0.005	4.3	0.0002	0.002	4.4E-06	0.00006	4.9E-07
Chromium	1	NA	0.0001	0.0005	ND	0.00002	ND
Manganese	0.047	NA	0.0028	0.026	ND	0.00100	ND
Thallium	8E-05	NA	0.033	0.30	ND	0.012	ND
SUM Hazard Index/ILCR			0.3	3	2E-04	0.1	2E-05

NOTES:

NA Not available
ND Not Determined due to lack of available information
lwa lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime excess Cancer Risk

Table 10.1.43
Hazard Quotients and Incremental Lifetime Cancer Risks
Dermal Contact With Surface Soil
SWMU 44 (Area 3) Zone C
Naval Base Charleston
Charleston, SC

Chemical	Dermal Adjustment	Oral RfD Used (mg/kg-day	Oral SF Used (mg/kg-day)-1	Potential Future Resident adult Hazard Quotient	Potential Future Resident child Hazard Quotient	Potential Futu Resident lwa ILCR	Potential Curren Worker adult Hazard Quotient	Potential Current Worker adult ILCR
Benzo(a)pyrene equiva	0.5	NA	14.6	ND	ND	3.6E-06	ND	1.5E-06
Aluminum	0.2	0.2	NA	0.003	0.01	ND	0.002	ND
Arsenic	0.2	6E-05	7.5	0.06	0.19	1.6E-05	0.04	6.7E-06
Beryllium	0.2	0.001	21.5	0.00004	0.0001	4.9E-07	0.00003	2.0E-07
Chromium	0.2	0.2	NA	0.00001	0.00004	ND	0.00001	ND
Manganese	0.2	0.0094	NA	0.0006	0.002	ND	0.0004	ND
Thallium	0.2	1.6E-05	NA	0.007	0.022	ND	0.005	ND
SUM Hazard Index/ILCR				0.07	0.23	2E-05	0.05	8E-06

NOTES:

NA Not available
ND Not Determined due to lack of available information
lwa lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime excess Cancer Risk
- Dermal to absorbed dose adjustment factor is applied to adjust for Oral SF and RfD (i.e., the oral RfD is based on oral absorption efficiency which should not be applied to dermal exposure and dermal CDI)

The computed hazard index for the adult resident was 0.3 for the soil ingestion pathway. The computed hazard index for the child ingestion pathway was 3, with aluminum (HQ=0.1), arsenic (HQ=2.7), and thallium (HQ=0.3) as the primary contributors. The dermal contact pathway hazard indices were 0.07 and 0.2 for adult residents and child residents, respectively. Arsenic was the primary contributor in both instances.

COCs identified for this scenario based on their contribution to risk/hazard are: aluminum, arsenic, beryllium, BEQs, and thallium.

Hypothetical Site Workers

Site worker ILCRs are 2E-5 and 8E-6 for the ingestion and dermal contact pathways, respectively. Arsenic and BEQs are the primary contributors for both pathways. The hazard indices for the ingestion and dermal hypothetical site worker are both projected to be less than or equal to 0.1.

COCs identified for this scenario based on their contribution to risk/hazard are arsenic and BEQs.

Nature and Extent of Surface Soil/Sediment COCs — Area 3

Aluminum, arsenic, beryllium, thallium, and BEQs were identified as COCs in SWMU 44 Area 3. Aluminum was detected in only one sample (044M012; 10,900 mg/kg) at a concentration exceeding the background reference concentration. As a result, chronic exposure to elevated aluminum concentrations is unlikely. Arsenic concentrations were elevated in both sediment samples collected in Area 3. Beryllium was detected in one sediment sample collected in this area. Although the reported beryllium concentration is above the residential RBC, the maximum (0.65 mg/kg; 044M012) is actually below background levels reported in other zones (Zone H — 1.46 mg/kg, Zone I — 3.17 mg/kg). Thallium was detected in both sediment samples collected in this area. No thallium detections were reported in Zone C background surface soil samples indicating that the concentrations reported in SWMU 44 Area 3 may be related to past or current site operations. As mentioned in *Exposure Point Concentrations*, SVOCs were analyzed on an extremely limited basis for SWMU 44 surface soil and sediment. The BEQ concentration used for ILCR projections in Area 3 was derived from the results for sample 044SB00701 collected in Area 1. Very little confidence can be placed in resultant ILCR projections for Area 3. These projections should be viewed as qualitative information indicating that surface soil and/or sediment BEQ concentrations in each area of SWMU 44 could pose an unacceptable risk.

Area 4

Tables 10.1.44 and 10.1.45 present the computed carcinogenic risks and/or HQs associated with the incidental ingestion of and dermal contact with Area 4 surface soil and sediment.

Hypothetical Site Residents

The ingestion ILCR (based on the adult and child lifetime weighted average) is 8E-6. The dermal pathway ILCR is 4E-6. BEQs are the sole contributor in both instances.

The computed hazard indices for the adult and child resident ingestion and dermal contact pathways are 0.1 or less.

COCs identified for this scenario based on their contribution to risk/hazard are BEQs.

Hypothetical Site Workers

Site worker ILCRs are 9E-7 and 1E-6 for the ingestion and dermal contact pathways, respectively. BEQs are the only contributors for both pathways. The hazard indices for the hypothetical site worker ingestion and dermal contact pathways were both projected to be less than 0.1.

COCs identified for this scenario based on their contribution to risk/hazard are BEQs.

Table 10.1.44
Hazard Quotients and Incremental Lifetime Cancer Risks
Incidental Surface Soil Ingestion
SWMU 44 (Area 4) Zone C
Naval Base Charleston
Charleston, SC

Chemical	Oral RfD Used (mg/kg-day)	Oral SF Used (mg/kg-day)-1	Potential Future Resident adult Hazard Quotient	Potential Future Resident child Hazard Quotient	Potential Futur Resident lwa ILCR	Potential Curren Worker adult Hazard Quotient	Potential Current Worker adult ILCR
Benzo(a)pyrene equivalent	NA	7.3	ND	ND	8.1E-06	ND	9.0E-07
Thallium	8E-05	NA	0.011	0.11	ND	0.004	ND
SUM Hazard Index/ILCR			0.01	0.1	8E-06	0.004	9E-07

NOTES:

NA Not available
ND Not Determined due to lack of available information
lwa lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime excess Cancer Risk

Table 10.1.45
Hazard Quotients and Incremental Lifetime Cancer Risks
Dermal Contact With Surface Soil
SWMU 44 (Area 4) Zone C
Naval Base Charleston
Charleston, SC

Chemical	Dermal Adjustment	Oral RfD Used (mg/kg-day	Oral SF Used (mg/kg-day)-1	Potential Future Resident adult Hazard Quotient	Potential Future Resident child Hazard Quotient	Potential Futu Resident lwa ILCR	Potential Curren Worker adult Hazard Quotient	Potential Current Worker adult ILCR
Benzo(a)pyrene equiva	0.5	NA	14.6	ND	ND	3.6E-06	ND	1.5E-06
Thallium	0.2	1.6E-05	NA	0.002	0.008	ND	0.002	ND
SUM Hazard Index/ILCR				0.002	0.008	4E-06	0.002	1E-06

NOTES:

NA Not available
ND Not Determined due to lack of available information
lwa lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime excess Cancer Risk
\- Dermal to absorbed dose adjustment factor is applied to adjust for Oral SF and RfD (i.e., the oral RfD is based on oral absorption efficiency which should not be applied to dermal exposure and dermal CDI)

Nature and Extent of Surface Soil/Sediment COCs – Area 4

Only BEQs were identified as COCs in SWMU 44 Area 4. As mentioned in *Exposure Point Concentrations*, SVOCs were analyzed on an extremely limited basis for SWMU 44 surface soil and sediment. The BEQ concentration used for ILCR projections in Area 4 was derived from the results for sample 044SB00701 collected in Area 1. Very little confidence can be placed in resultant ILCR projections for Area 4. These projections should be viewed as qualitative information indicating that surface soil and/or sediment BEQ concentrations in each area of SWMU 44 could pose an unacceptable risk.

Overall SWMU 44

Adolescent Trespasser

Tables 10.1.46 and 10.1.47 present the computed carcinogenic risks and/or HQs associated with the incidental ingestion of and dermal contact with overall SWMU 44 surface soil and sediment by adolescent trespassers. The ingestion ILCR is 5E-6, and the dermal pathway ILCR is 1E-5. Arsenic is the only significant contributor for the ingestion and dermal contact pathways.

The computed hazard index is 0.09 for the soil ingestion pathway, and 0.2 for the dermal contact pathway. Arsenic is the primary contributor for both pathways.

The only COC identified for this scenario based on its contribution to risk/hazard is arsenic, which was detected above the background reference concentration at eight of 19 surface soil and sediment sampling locations.

Groundwater Pathways

SWMU 44 groundwater is not currently used as a potable or process water source. Exposure to groundwater onsite was evaluated site-wide under both residential and industrial scenarios. For these scenarios, the ingestion exposure pathway was evaluated assuming the site will be used in

Table 10.1.46
Hazard Quotients and Incremental Lifetime Cancer Risks
Incidental Surface Soil/Sediment Ingestion
SWMU 44 Zone C
Naval Base Charleston
Charleston, SC

Chemical	Oral RfD Used (mg/kg-day)	Oral SF Used (mg/kg-day)-1	Potential Future Adolescent Trespasser Hazard Quotient	Potential Future Adolescent Trespasser ILCR
Benzo(a)pyrene Equivalent	NA	7.3	ND	1.2E-07
Aluminum	1	NA	0.003	NA
Arsenic	0.0003	1.5	0.072	4.6E-06
Beryllium	0.005	4.3	0.00006	1.9E-07
Chromium	0.005	NA	0.0019	ND
Manganese	0.047	NA	0.0006	ND
Thallium	8E-05	NA	0.0091	ND
SUM Hazard Index/ILCR			0.09	5E-06

NOTES:

NA Not available
ND Not Determined due to lack of available information
ILCR Incremental Lifetime excess Cancer Risk

Table 10.1.47
Hazard Quotients and Incremental Lifetime Cancer Risks
Dermal Contact with Surface Soil/Sediment
SWMU 44 Zone C
Naval Base Charleston
Charleston, SC

Chemical	Dermal Adjustment	Oral RfD Used (mg/kg-day	Adjusted Oral SF Used (mg/kg-day)-1	Potential Future Adolescent Trespasse Hazard Quotient	Potential Future Adolescent Trespasse ILCR
Benzo(a)pyrene Equiv	0.5	NA	14.6	ND	9.6E-08
Aluminum	0.2	0.2	NA	0.0057	ND
Arsenic	0.2	6E-05	7.5	0.15	9.5E-06
Beryllium	0.2	0.001	21.5	0.00013	4.0E-07
Chromium	0.2	0.001	NA	0.00040	ND
Manganese	0.2	0.0094	NA	0.00011	ND
Thallium	0.2	1.6E-05	NA	0.0019	ND
SUM Hazard Index/ILCR				0.16	1E-05

NOTES:

NA Not available
ND Not Determined due to lack of available information
ILCR Incremental Lifetime excess Cancer Risk
- Dermal to absorbed dose adjustment factor is applied to adjust for Oral SF and RfD (i.e., the oral RfD is based on oral absorption efficiency which should not be applied to dermal exposure and dermal CDI)

the future for residential purposes and that an unfiltered well, drawing from the shallow water-bearing zone, will be used as the domestic water source. For noncarcinogenic contaminants evaluated relative to future site residents, hazard was computed separately to address child and adult exposure.

Shallow Groundwater

Table 10.1.48 presents the risk and hazard for the ingestion exposure pathway for shallow groundwater.

Hypothetical Site Residents

The shallow groundwater ingestion ILCR for hypothetical site residents is 2E-3. Arsenic, beryllium, bis(2-ethylhexyl)phthalate, and 2,3,7,8-TCDD equivalents were the primary contributors. The hazard indices for the ingestion pathway for the adult and child resident are 6 and 13, respectively. Aluminum, arsenic and manganese were the primary contributors. No volatile COPCs were identified in the shallow aquifer; consequently, the inhalation pathway was not evaluated.

COCs identified for this scenario based on their contribution to risk/hazard are: aluminum, antimony, arsenic, beryllium, bis(2-ethylhexyl)phthalate, 2,3,7,8-TCDD equivalents, manganese, and nickel.

Hypothetical Site Workers

The shallow groundwater risk posed to future site workers is 6E-4 ILCR for the ingestion exposure pathway. Arsenic and beryllium are the primary contributors. The hazard index for the ingestion exposure pathway was calculated to be 2. Manganese, arsenic and aluminum are the primary contributors in decreasing order of significance.

Table 10.1.48
Hazard Quotients and Incremental Lifetime Cancer Risks
Shallow Groundwater Ingestion
SWMU 44 Zone C
Naval Base Charleston
Charleston, SC

Chemical	Oral RfD Used (mg/kg-day)	Oral SF Used (mg/kg-day)-1	Potential Future Resident adult Hazard Quotient	Potential Future Resident child Hazard Quotient	Potential Futur Resident lwa ILCR	Potential Future Worker adult Hazard Quotient	Potential Future Worker adult ILCR
Aluminum	1	NA	1.0	2.4	ND	0.37	ND
Antimony	0.0004	NA	0.3	0.6	ND	0.10	ND
Arsenic	0.0003	1.5	1.4	3.3	3.5E-04	0.50	1.1E-04
Beryllium	0.005	4.3	0.1	0.3	1.4E-03	0.04	4.5E-04
Bis(2-Ethylhexyl)phth	0.02	0.014	0.011	0.026	1.7E-06	0.0039	5.4E-07
Lead	NA	NA	ND	ND	ND	ND	ND
Manganese	0.023	NA	2.4	5.5	ND	0.8	ND
Nickel	0.02	NA	0.30	0.71	ND	0.11	ND
2,3,7,8-TCDD equival	NA	150000	ND	ND	1.2E-06	ND	3.9E-07
Acetophenone	0.1	NA	0.0003	0.0006	ND	0.0001	ND
SUM Hazard Index/ILCR			6	13	2E-03	2	6E-04

NOTES:

NA Not available
ND Not Determined due to lack of available information
lwa lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime excess Cancer Risk

COCs identified for this scenario based on their contributions to risk/hazard are aluminum, arsenic, beryllium, and manganese.

Current Site Workers

Shallow groundwater is not currently used as a potable water source for SWMU 44 or other areas of Zone C. In the absence of a completed exposure pathway, no threat to human health is posed by reported shallow groundwater contamination.

Lead Toxicity

The maximum shallow groundwater lead concentration reported at SWMU 44 (19.8 μg/L) is above the USEPA Office of Water treatment technique action level of 15 μg/L. The second highest lead concentration is 9.65 μg/L, and the mean for all SWMU 44 shallow monitoring wells was computed to be 6.8 μg/L. As a result, shallow groundwater lead concentrations reported at SWMU 44 are not considered to pose a significant threat to hypothetical future site residents. Subsequent quarterly groundwater results showed lead levels (in the maximally impacted well) below the TTAL (ND to 5.7 μg/l). These data corroborate the conclusion based on first quarter samples.

Nature and Extent of Shallow Groundwater COCs – SWMU 44

Aluminum, antimony, arsenic, beryllium, bis(2-ethylhexyl)phthalate, nickel, 2,3,7,8-TCDD equivalents and manganese were identified as COCs in SWMU 44 shallow groundwater based on hypothetical future resident potable use. Only one of eight aluminum detections in groundwater (well 044001; 38 mg/L) exceeded the tap water RBC. Results from well 004001 remained above RBC and reference concentrations in subsequent quarterly samples.

Arsenic was detected in four wells, with each concentration above the tap water RBC. Arsenic was detected in Zone C background monitoring wells, and as a result, a reference concentration of 0.0061 mg/l was computed. The maximum concentration at SWMU 44 (15.3 μg/L) is below the reference concentrations computed for other zones (Zone H — 27.9 μg/L; Zone I — 35.0 μg/L) as well as the MCL of 50 μg/L. Arsenic was detected above its reference concentration in wells 044001 and 044004 during subsequent quarterly sampling events, but did not exceed the MCL in any instance.

Antimony was detected in samples collected from two of eight shallow monitoring wells at SWMU 44 (044001 and 044004). Antimony was detected consistently at less than μg/l during rounds 2 through 5 in wells 044001, 044003, 044004, 044006, and 044008. Beryllium was detected in only one SWMU 44 shallow monitoring well (044001). The concentration at this location (21.9 μg/L) is well above the tap water RBC and the MCL (4 μg/L). The isolated detection of beryllium suggests that chronic exposure at the EPC is unlikely. Beryllium levels remain high in well 044001 in subsequent quarters, with concentrations ranging from 17.5 to 32.9 μg/l. It was detected sporadically in other SWMU 44 wells in rounds 2 through 5. BEHP was detected in one sample (044GW00601) at a concentration of 8μg/L. This compound is a common laboratory contaminant and detections in this range are often related to exogenous sources. Second quarter shallow groundwater data should be evaluated to confirm or refute the presence of BEHP. BEHP was detected at 1 μg/l second quarter but was nondetected in all subsequent rounds.

Seven of eight reported manganese concentrations exceeded both the tap water RBC and the Zone C reference concentration. Manganese levels were fairly consistent across SWMU 44 ranging from 418 to 1,940 μg/L compared to the reference concentration of 608 μg/L. The maximum concentration was reported in sample 044GW00101. The distribution of manganese concentrations in shallow groundwater roughly mimics that of iron, suggesting a relationship between the source of the two elements. The SWMU 44 area has reportedly received a significant amount of fill material over time as tidal marshes were reclaimed for use at NAVBASE. Placement of iron (and manganese) rich sediment (dredge material) at SWMU 44 could account for concentrations elevated relative to reference locations that had not been similarly affected. Elevated manganese concentrations were reported routinely through subsequent quarterly sampling events.

Nickel was detected at concentrations above the tap water RBC at two locations (044MW001 and 044MW003). The relative nickel concentration distribution also mimic those of iron in shallow groundwater. As a result, the same source as that postulated for manganese is also plausible for nickel. The mean nickel concentration at SWMU 44 (41.6 μg/L) is below the tap water RBC. Nickel concentrations remain elevated in these two wells.

2,3,7,8-TCDD equivalents were detected in the one shallow groundwater sample analyzed at a concentration of 5.4E-10 mg/L. Due to the hydrophobic nature of dioxins, they are not expected to migrate from soil to groundwater. It has been suspected that first-quarter results may reflect the influence of sediment entrained in the monitored zone during well installation. Consideration of future quarterly sampling results will confirm or refute the presence of 2,3,7,8-TCDD equivalents in shallow groundwater. This review will facilitate responsible and sound risk management decisions. Low level 2,3,7,8-TCDD equivalent hits (<2E-10 mg/l) were reported in round 2 through 4 samples from well 044004.

COCs Identified

Identification of chemicals of concern was based on cumulative (all pathway) risk and hazard projected for SWMU 44. COCs were selected for surface soil, sediment, and shallow groundwater. USEPA has established a generally acceptable risk range of 1E-4 to 1E-6, and a hazard index threshold of 1.0 (unity). In Zone C BRAs, a COC was considered to be any chemical contributing to a cumulative risk level of 1E-6 or greater and/or a cumulative hazard index above 1.0, if its individual ILCR exceeds 1E-6 or its hazard quotient exceeds 0.1. For carcinogens, this approach is relatively conservative, because a cumulative risk level of 1E-4 (and individual ILCR of 1E-6) is recommended by USEPA Region IV as the trigger for establishing COCs. The COC selection algorithm presented was used to provide a more comprehensive evaluation of chemicals contributing to carcinogenic risk or noncarcinogenic hazard during the remedial goal options development process. Table 10.1.49 summarizes the COCs identified at SWMU 44 on a medium- and area-specific basis.

10.1.10.6 Risk Uncertainty

Characterization of Exposure Setting and Identification of Exposure Pathways

The potential for high bias is introduced through exposure setting and pathway selection due to the highly conservative assumptions (i.e., future residential use) recommended by USEPA Region IV when assessing potential future and current exposure. The exposure assumptions made in the site worker scenario are highly protective and would tend to overestimate exposure.

Site workers are exposed to surface soils when walking across the site or during maintenance activities. However, site workers would not be expected to work onsite in contact with affected media for eight hours per day, 250 days per year as assumed in the exposure assessment. Most of SWMU 44 is poorly drained filled tidal marsh. The characteristics of this type of environment tend to minimize frequent foot traffic and thus contact with affected surface soil and sediment. Furthermore, access to certain areas, particularly in the northern portion of the SWMU, are restricted by dense vegetation which would further reduce the potential for exposure. Performing maintenance activities onsite 52 days per year would result in one-fifth the projected risk/hazard for site workers. In addition, maintenance activities would likely be restricted to areas immediately adjacent to the rail lines and coal offload trestles.

Table 10.1.49
Summary of Risk and Hazard-based COCs
SWMU 44 Zone C
NAVBASE - Charleston
Charleston, South Carolina

Medium	Exposure Pathway		Area 1 Resident	Area 1 Worker	Area 2 Resident	Area 2 Worker	Area 3 Resident	Area 3 Worker	Area 4 Resident	Area 4 Worker	Adolescent Trespasser
Surface Soil/ Sediment	Incidental Ingestion	Benzo(a)pyrene equival	X-c		X-c		X-c		X-c		
		Chromium									
		Aluminum	X-nc				X-nc				
		Arsenic	X-c,nc	X-c	X-nc,c	X-c	X-nc,c	X-c			X-c
		Beryllium	X-c	X-c	X-c		X-c				
		Manganese					X-				
		Thallium	X-nc		X-nc		X-nc		X-nc		
	Dermal Conta	Benzo(a)pyrene equival	X-c	X-c	X-c	X-c	X-c	X-c	X-c	X-c	
		Chromium									
		Aluminum									
		Arsenic	X-nc,c	X-c	X-nc,c	X-c	X-nc,c	X-c			X-c
		Beryllium	X-c		X-c						
		Manganese									
		Thallium									
Surface Soil/Sediment Pathway ILCR Sum			3E-04	3E-05	4E-04	5E-05	2E-04	3E-05	1E-05	2E-06	1E-05
Surface Soil/Sediment Pathway Cumulative Hazard Index			5.7	0.3	6.7	0.3	3.5	0.2	0.1	0.01	0.3
Shallow Groundwater	Ingestion	Aluminum	X-nc	X-nc							
		Antimony	X-nc	X-nc							
		Arsenic	X-nc,c	X-nc,c							
		Beryllium	X-nc,c	X-c							
		Bis(2-Ethylhexyl)phthal	X-c								
		Lead									
		Manganese	X-nc	X-nc							
		Nickel	X-nc								
		2,3,7,8-TCDD equivalen	X-c								
		Acetophenone									
Shallow Groundwater Pathway ILCR Sum			2E-03	6E-04							
Shallow Groundwater Pathway Cumulative Hazard Index			33	5							

Notes:
ND indicates not determined due to the lack of available risk information.
ILCR indicates incremental excess lifetime cancer risk
HI indicates hazard index
X-nc indicates chemical is a COC by virtue of projected noncarcinogenic hazard quotient
X-c indicates chemical is a COC by virtue of projected ILCR.
X-nc,c indicates chemical is a COC by virtue of both projected noncarcinogenic hazard quotient and ILCR
Shallow groundwater pathway risk/hazard projections were not segregated by area.
For each area/medium/pathway, the resident cumulative hazard index is based on the child receptor.

Residential use of the site would not be expected, based on current site uses and the nature of the parcel. Current reuse plans call for continued nonresidential use of the SWMU 44 land, specifically as open buffer space. If this area were used as a residential site, extensive site alteration would be necessary. As previously discussed, much of the parcel west of the railroad tracks is poorly drained former tidal marsh. During the RFI, it was noted that the drainage ditch which forms the western site boundary and other areas in SWMU 44 are occasionally flooded during high tide. As a result, extensive filling and/or regrading would be necessary in order to render the parcel fit for private residential development. Due to the nature of the former site operations, the portions of the site close to the raillines and coal offload trestles would likely require some form of surface soil regrading to address purely aesthetic issues, as coal dust and other residuum are present throughout these areas. Rail lines would be removed as a matter of course as part of residential development.

No site features in SWMU 44 would have a pronounced impact on adolescent trespasser exposure to any specific area. Although physical impediments exist such as *pluff mud,* poorly drained soil and dense vegetation, it is still possible that infrequent surface soil and sediment contact could occur. Infrequent exposure (26 days/year) was assumed for this group to account for these conditions. The entire investigative area comprises approximately fourteen acres, and the most heavily impacted (from an inorganic COC perspective) areas appear to be concentrated in the extreme northern portion of the site and the western drainage ditch. No modification of EPCs was made to account for contaminant distributions when addressing the adolescent trespasser scenario.

Shallow groundwater is not currently used at SWMU 44 for potable or industrial purposes. A basewide system provides drinking and process water to buildings and parcels throughout Zone C. This system is slated to remain in operation under the current base reuse plan. As a result, shallow groundwater would not be expected to be used under future site use scenarios. Therefore, the scenario established to project risk/hazard associated with shallow groundwater exposure is highly conservative, and associated pathways are not expected to be completed in the future.

Determination of Exposure Point Concentrations

The maximum concentrations reported in shallow groundwater were used to calculate risk/hazard for all COPCs. The use of maximum reported concentrations is expected to result in an overestimate of CDI and the resulting risk/hazard. In surface soil, the maximum concentrations of COPCs identified in four distinct areas were used to calculate potential exposure. A high degree of uncertainty exists relative to quantification of soil semivolatile exposure. A single sample was considered to represent semivolatile concentrations across the SWMU. Due to the limited information, the degree to which this assumption affects risk/hazard estimates can not be adequately estimated.

Frequency of Detection and Spatial Distribution

In each of the four areas broken out for assessment of surface soil and sediment risk/hazard, the maximum concentration of each COPC was used to calculate potential exposure. The distribution of each COC identified for surface soil and sediment is discussed in Section 10.1.10.5. The following discussion outlines how these distributions affect the confidence that can be placed in exposure estimates as well as any measures of variability. Because most of SWMU 44 has reportedly been filled over time for land reclamation, it is not unexpected that the composition of soil and sediment at this site resembles that of other areas (Zone H and Zone I) that were also reclaimed. As a result, SWMU 44 soil and sediment results are compared (where applicable) to reference concentrations for these other zones.

Aluminum, arsenic, beryllium, thallium, and BEQs were identified as COCs in SWMU 44 surface soil and sediment. However, aluminum, beryllium, and manganese concentrations in soil and sediment are below reference concentrations for Zones H and I. There is also no recognizable correlation between the concentrations of these elements at SWMU 44 and those of arsenic and thallium which appear to be related to site operations as discussed below. Due to the similarities in material origin between SWMU 44 and Zones H and I, it can be reasoned that observed concentrations of aluminum, beryllium, and manganese indicate naturally occurring and/or non SWMU-related anthropogenic levels in the parent material (dredge spoils and other imported fill material). As a result, it cannot be definitively concluded that the risk/hazard projections made for these elements in each SWMU 44 area indicate a threat to human health in excess of that posed by nonimpacted media.

Arsenic concentrations are generally elevated above the Zone C background reference concentration (24.94 mg/kg) in numerous surface soil and sediment samples collected throughout SWMU 44. For comparison, the reference concentration for this element was 14.8 mg/kg in Zone H. Eight of 19 surface soil and sediment samples collected at SWMU 44 reported arsenic concentrations in excess of the Zone H background reference concentration. These comparisons suggest that arsenic concentrations are truly elevated in the affected samples. It may be concluded that current and former site operations have served as a source of arsenic.

Thallium, which was detected in six of 19 surface soil and sediment samples collected at SWMU 44, was not detected in Zone C background surface soil samples. The corresponding Zone H background reference concentration was computed to be 0.63 mg/kg. Each reported detection at SWMU 44 exceeded this alternate background estimate, indicating that the concentrations reported in SWMU 44 may be related to past or current site operations.

In shallow groundwater, the maximum concentrations of aluminum, antimony, beryllium, lead manganese and nickel were reported in monitoring well 044001. This well is located east of the coal offload trestles close to a surface water runoff collection point. First-quarter results support at least two hypotheses. The first is that surface water runoff has led to an accumulation of inorganic parameters in local sediment and shallow groundwater as contaminants were transported from the coal offloading area. The second hypothesis is that sediments entrained in the borehole annular space during well construction were sampled along with the liquid phase, and that first-quarter analytical results indicate elevated concentrations due to solid phase contributions. Subsequent quarterly monitoring results should serve to confirm or refute these hypotheses.

Quantification of Risk/Hazard

As indicated by the discussions above, the uncertainty inherent in the risk assessment process is great. In addition, many site-specific factors have affected the uncertainty of this assessment that would upwardly bias the risk and hazard estimates. Exposure pathway-specific sources of uncertainty are discussed below.

Soil

Of the CPSSs screened and eliminated from formal assessment because they did not exceed the corresponding RBCs, none was reported at a concentration within 10% of its RBC. This minimizes the likelihood of potentially significant cumulative risk/hazard with respect to the eliminated CPSSs.

Central tendency analysis was not formally performed for SWMU 44 surface soil and sediment, but a simplified approach was taken to assess the potential influences of CT assumptions. The central tendency assumption for residential exposure duration is 9 years compared to the 30-year assumption for RME. The CT exposure frequency assumption is 234 days/year compared to 350 days/year RME. The traditional CT ingestion rate assumptions reduce adult and child rates by 50%. If all other exposure assumptions remain fixed, application of the CT exposure duration and frequency as well as ingestion rates would result in risk and hazard projections approximately 90% below the RME. At CT, the residential surface soil and sediment pathway related risk (incidental ingestion and dermal contact) would fall below 1E-4 but remain above the 1E-6 point of departure for Areas 1, 2 and 3. The cumulative hazard index for ingestion and dermal contact pathways for the child resident would also fall below unity under CT assumptions. In Area 4, application of CT assumptions would result in a ILCR projection of 1E-6 (at the point of departure), and a cumulative hazard index below unity.

Although the future land use at this site is unknown, worker, residential and adolescent trespasser exposure scenarios were assessed in this HHRA. The area encompassed by SWMU 44 is scheduled to become open buffer space under current base reuse plans.

Groundwater

Of the CPSSs screened and eliminated from formal assessment, none was reported at concentrations close to the corresponding RBCs (i.e., within approximately 10% of the RBC). This minimizes the likelihood of potentially significant cumulative risk/hazard with respect to the eliminated CPSSs.

Central tendency analysis was not formally performed for SWMU 44 shallow groundwater, but a simplified approach was taken to assess the potential influences of CT assumptions. The central tendency assumption for residential exposure duration is 9 years compared to the 30-year assumption for RME. The CT exposure frequency assumption is 234 days/year compared to 350 days/year RME. If all other exposure assumptions remain fixed, application of the CT exposure duration and frequency would result in risk and hazard projections approximately 80 percent below the RME. At CT, the residential shallow groundwater pathway-related risk (ingestion) would remain above 1E-4 due to the contributions of arsenic and beryllium to overall projections. The adult and child resident shallow groundwater hazard indices would remain above unity.

In consideration of the potential sources of shallow groundwater COCs (and thus risk/hazard projections), consideration of subsequent quarterly sampling results should be used to confirm or refute the presence of groundwater COCs. This review will be imperative to facilitate responsible and sound risk management decisions.

10.1.10.7 Risk Summary

The risk and hazard posed by contaminants at SWMU 44 were assessed for the hypothetical site worker and the hypothetical future site resident under reasonable maximum exposure assumptions. In addition, an adolescent trespasser scenario was addressed relative to potential surface soil and sediment exposure. For surface soil and sediment, the incidental ingestion and dermal contact pathways were assessed in this BRA. The ingestion pathway was evaluated for shallow groundwater based on first quarter groundwater monitoring data. Table 10.1.50 summarizes risk for each pathway/receptor group evaluated for SWMU 44.

10.1.10.8 Remedial Goal Options

Soil/Sediment

Surface soil and sediment RGOs for carcinogens presented in Tables 10.1.51 and 10.1.52 were based on the lifetime weighted average site resident and adult site worker, respectively. Hazard-based RGOs were calculated based on either the hypothetical child resident or the adult site worker, as noted in each of the corresponding tables. Table 10.1.53 presents the RGOs applicable to the adolescent trespasser scenario.

Groundwater

Shallow groundwater RGOs based on site residents and site workers are shown in Tables 10.1.54 and 10.1.55, respectively.

Table 10.1.50
Risk and Hazard Summary
SWMU 44 Zone C
NAVBASE - Charleston
Charleston, South Carolina

Medium	Exposure Pathway		Area 1 Resident	Area 1 Worker	Area 2 Resident	Area 2 Worker	Area 3 Resident	Area 3 Worker	Area 4 Resident	Area 4 Worker	Adolescent Trespasser
Surface Soil/ Sediment	Incidental Ingestion	ILCR	2.6E-04	2.9E-05	3.3E-04	3.7E-05	1.6E-04	1.7E-05	8.1E-06	9.0E-07	4.9E-06
		HI	5.4	0.2	6.2	0.2	3.1	0.1	0.1	0.004	0.1
	Dermal Contact	ILCR	3.2E-05	1.3E-05	4.0E-05	1.7E-05	2.0E-05	8.2E-06	3.6E-06	1.5E-06	1.0E-05
		HI	0.4	0.1	0.5	0.1	0.2	0.1	0.008	0.002	0.2
Surface Soil/Sediment Pathway ILCR Sum			3E-04	4E-05	4E-04	5E-05	2E-04	3E-05	1E-05	2E-06	1E-05
Surface Soil/Sediment Pathway Cumulative HI			5.8	0.3	6.7	0.3	3.3	0.2	0.1	0.01	0.3
Shallow Groundwater	Ingestion	ILCR	1.8E-03	5.6E-04							
		HI	33	5							
Shallow Groundwater Pathway ILCR Sum			2E-03	6E-04							
Shallow Groundwater Pathway Cumulative HI			33	5							

Notes:
ND indicates not determined due to the lack of available risk information.
ILCR indicates incremental excess lifetime cancer risk
HI indicates hazard index
Shallow groundwater pathway risk/hazard projections were not segregated by area.

For each area/medium/pathway, the resident cumulative hazard index is based on the child receptor.

Table 10.1.51
Residential-Based Remedial Goal Options Surface Soil
SWMU 44 Zone C
Naval Base Charleston
Charleston, South Carolina

Chemical	Slope Factor (mg/kg-day)-1	Reference Dose (mg/kg-day)	FI/FC Factor	Unadjusted EPC mg/kg	Hazard-Based Remedial Goal Options 3 mg/kg	1 mg/kg	0.1 mg/kg	Risk-Based Remedial Goal Options 1E-06 mg/kg	1E-05 mg/kg	1E-04 mg/kg	Background Concentrati mg/kg	Applicable SWMU 44 Area(s)
Benzo(a)pyrene equiva	7.3	NA	1	0.710	ND	ND	ND	0.06	0.6	6	NA	1,2,3,4
Aluminum	NA	1	1	17500	218781	72927	7293	ND	ND	ND	9990	1,3
Arsenic	1.5	0.0003	1	103	65.6	21.9	2.2	0.38	3.8	38	14.2	1,2,3,4
Beryllium	4.3	0.005	1	2	1094	365	36	0.13	1.3	13	ND	1,2,3
Thallium	NA	8E-05	1	4.6	17.5	5.8	0.58	ND	ND	ND	ND	1,2,3

NOTES:

EPC exposure point concentration
NA not applicable
ND not determined
- remedial goal options were based on the residential lifetime weighted average for carcinogens and the child resident for noncarcinogens

Applicable SWMU 44 indicates the designated area in which the chemical was identified as a COC,

Table 10.1.52
Worker-Based Remedial Goal Options Surface Soil
SWMU 44 Zone C
Naval Base Charleston
Charleston, South Carolina

Chemical	Slope Factor (mg/kg-day)-1	Reference Dose (mg/kg-day)	FI/FC Factor	Unadjusted EPC mg/kg	**Hazard-Based Remedial Goal Options** **3** mg/kg	**1** mg/kg	**0.1** mg/kg	**Risk-Based Remedial Goal Options** **1E-06** mg/kg	**1E-05** mg/kg	**1E-04** mg/kg	Background Concentrati mg/kg	Applicable SWMU 44 Area
Benzo(a)pyrene equiva	7.3	NA	1	0.7095	ND	ND	ND	0.30	3.0	30	NA	1,2,3,4
Arsenic	1.5	0.0003	1	103	1305	435	43.5	2.71	27.1	271	14.2	1,2,3
Beryllium	4.3	0.005	1	2.0	21745	7248	725	0.94	9.4	94	ND	1

NOTES:

EPC exposure point concentration
NA not applicable
ND not determined

Table 10.1.53
Trespasser-Based Remedial Goal Options
SWMU 44 Zone C
Naval Base Charleston
Charleston, South Carolina

Chemical	Slope Factor (mg/kg-day)-	Reference Dose (mg/kg-day)	Unadjusted EPC mg/kg	Hazard-Based Remedial Goal Options 3 mg/kg	1.0 mg/kg	0.1 mg/kg	Risk-Based Remedial Goal Options 1E-06 mg/kg	1E-05 mg/kg	1E-04 mg/kg	Background Concentration mg/kg
Arsenic	1.5	0.0003	137	ND	ND	ND	9.7	96.7	967	24.96

NOTES:
EPC exposure point concentration
NA not applicable
ND not determined

Table 10.1.54
Residential-Based Remedial Goal Options Shallow Groundwater
SWMU 44 Zone C
Naval Base Charleston
Charleston, South Carolina

Chemical	Oral SF (mg/kg-day)	Inh. SF (mg/kg-day)	Oral RfD (mg/kg-day	Inh RfD (mg/kg-day	Unadj. EPC mg/l	Hazard-Based Remedial Goal Optio 0.1 mg/l	1.0 mg/l	3 mg/l	Risk-Based Remedial Goal Options 1E-06 mg/l	1E-05 mg/l	1E-04 mg/l	ARAR mg/l	Background Concentrati mg/l
Aluminum	NA	NA	1	NA	38	1.6	15.6	46.9	ND	ND	ND	0.2	0.41
Antimony	NA	NA	0.0004	NA	0.0039	0.0006	0.006	0.02	ND	ND	ND	0.006	ND
Arsenic	1.5	NA	0.0003	NA	0.0153	0.0005	0.005	0.01	0.00004	0.0004	0.0044	0.05	0.0061
Beryllium	4.3	NA	0.005	NA	0.0219	0.0078	0.078	0.23	0.00002	0.0002	0.0015	0.004	0.00033
Bis(2-Ethylhexyl)phth	0.014	NA	0.02	NA	0.008	0.031	0.31	0.94	0.005	0.047	0.47	0.006	NA
Lead	NA	NA	NA	NA	0.0198	ND	ND	ND	ND	ND	ND	0.015	0.0033
Manganese	NA	NA	0.023	NA	1.99	0.0360	0.360	1.08	ND	ND	ND	0.05	0.608
Nickel	NA	NA	0.02	NA	0.221	0.031	0.31	0.94	ND	ND	ND	0.1	0.0036
2,3,7,8-TCDD equival	150000	NA	NA	NA	5.4E-10	ND	ND	ND	4.4E-10	4.4E-09	4.4E-08	3E-08	NA

NOTES:

EPC exposure point concentration
NA not applicable
ND not determined
\- remedial goal options were based on the residential lifetime weighted average for carcinogens and the child resident for noncarcinogens

Table 10.1-55
Worker-Based Remedial Goal Options Shallow Groundwater
SWMU 44 Zone C
Naval Base Charleston
Charleston, South Carolina

Chemical	Oral SF (mg/kg-day)	Inh. SF (mg/kg-day)	Oral RfD (mg/kg-day	Inh RfD (mg/kg-day	Unadj. EPC mg/l	Hazard-Based Remedial Goal Optio 0.1 mg/l	1.0 mg/l	3 mg/l	Risk-Based Remedial Goal Options 1E-06 mg/l	1E-05 mg/l	1E-04 mg/l	ARAR mg/l	Background Concentrati mg/l
Aluminum	NA	NA	1	NA	38	10.22	102.2	1022	ND	ND	ND	0.2	0.41
Arsenic	1.5	NA	0.0003	NA	0.0153	0.003	0.03	0.31	0.0001	0.001	0.014	0.05	0.0061
Beryllium	4.3	NA	0.005	NA	0.0219	0.051	0.51	5.11	0.00005	0.0005	0.005	0.004	0.00033
Lead	NA	NA	NA	NA	0.0198	ND	ND	ND	ND	ND	ND	0.015	0.0033
Manganese	NA	NA	0.023	NA	1.99	0.235	2.35	23.51	ND	ND	ND	0.05	0.608
Nickel	NA	NA	0.02	NA	0.221	0.204	2.04	20.44	ND	ND	ND	0.1	0.00359

NOTES:
- EPC exposure point concentration
- NA not applicable
- ND not determined

10.1.11 Interim Measure

Site History: The Detachment completed an interim measure in September 1996 which resulted in the removal of approximately 13,246 tons of coal and a coal/dirt mixture. The interim action location and sampling locations have not yet been surveyed. Figures showing sampling locations and the removal action boundary will provided under separate cover. The interim measure was based on a "visual" removal and no confirmation samples were collected at that time.

Confirmation Sampling

Nine confirmation soil samples were collected from 0 to 6 inches depth at nine locations. Only the surface interval was collected because during the original sampling event only one of eight subsurface soil samples could be collected because of the shallow water table. Soil samples were analyzed for metals and semivolatiles. In addition, groundwater samples were collected from all SWMU 44 monitoring wells and analyzed for metals and SVOCs. Monitoring well NBC-044-008 was also analyzed for pesticides/PCBs and VOCs due to concerns at nearby AOC 700.

The report previously provided residential remedial goal options for benzo(a)pyrene equivalents (BEQ), arsenic, beryllium, and thallium which were the risk and hazard drivers in the soil at SWMU 44. The confirmation sample results have been compared to the RGOs to determine the effectiveness of the removal action.

Nature and Extent of Soil Contamination at SWMU 44

Soil analytical results are in Table 10.1.56. Appendix D is a complete analytical report for Zone C, and Appendix H contains detection only summary tables. BEQs exceed the 1E-06 residential risk-based RGO at seven locations. Arsenic was above the hazard-based residential RGO of 21.9 mg/kg in four samples and was above the risk-based residential RGO of 0.38 mg/kg in all nine samples. Beryllium did not exceed its hazard-based residential RGO of 365 mg/kg, but it did exceed its risk-based residential RGO of 0.13 mg/kg at all nine locations. Thallium, which was identified as a COC, was not detected in the confirmation soil samples.

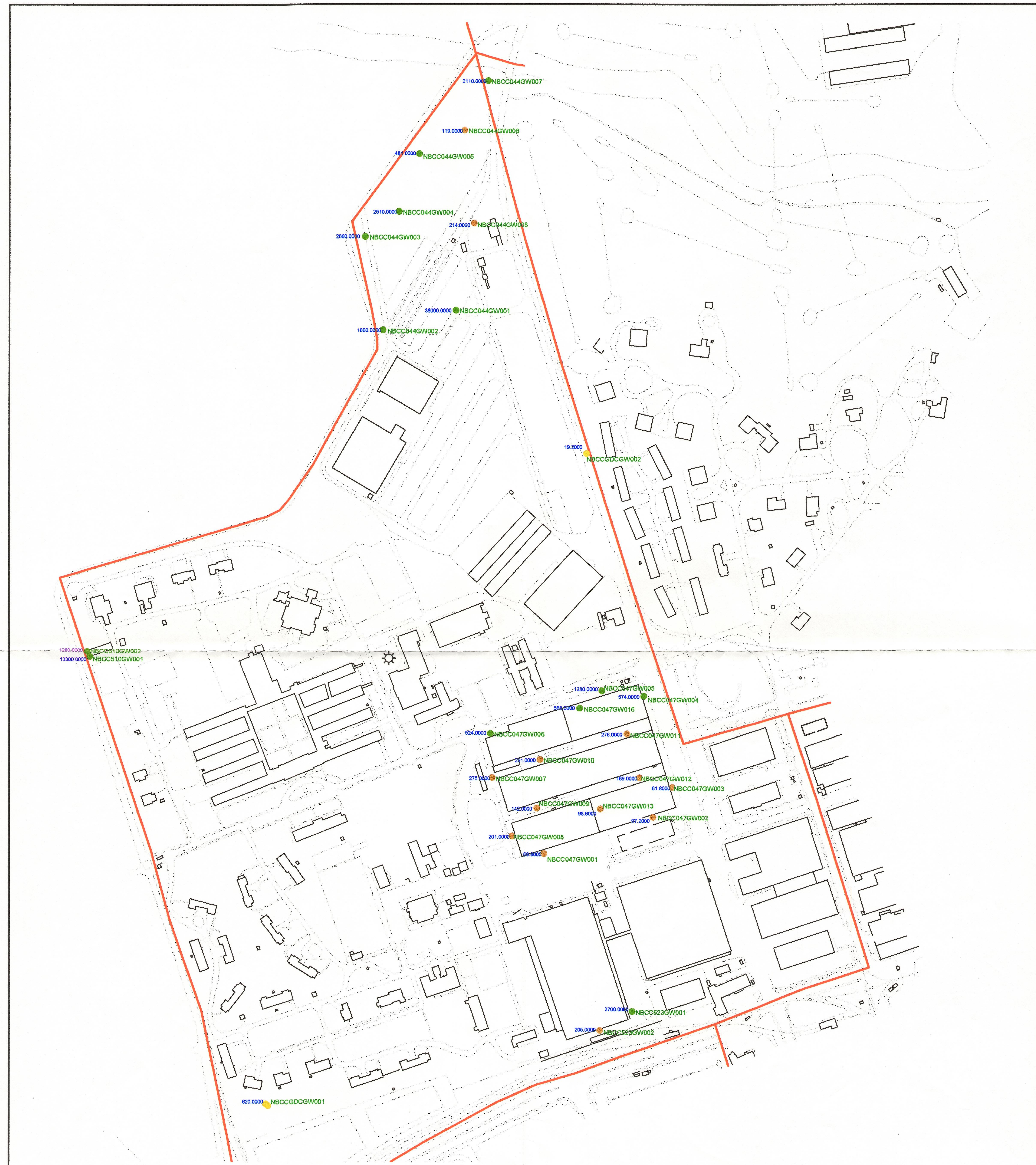
Table 10.1.56
Comparison of Confirmation Soil Samples to Residential RGOs
SWMU 44 – Coal Storage Area

Analyte	Sample Interval	Frequency of Detection	Range of Detection	Mean	Residential Risk RGO/ Hazard RGO	Number of Samples Exceeding RGO
SVOCs (μg/kg)						
BEQs	Upper	7/9	14.84 - 4,242.3	753.68	60	6
Inorganics (mg/kg)						
Arsenic	Upper	9/9	3.30 - 98.50	30.52	21.9/0.38[a]	4/9
Beryllium	Upper	9/9	0.49 - 1.20	0.85	365/0.13	0/9

Notes:
BEQs = benzo(a)pyrene equivalents
21.9/.38 = 21.9 mg/kg is a hazard based RGO and 0.38 mg/kg is a risk-based RGO.
ND = Not determined

Nature and Extent of Groundwater Contamination at SWMU 44

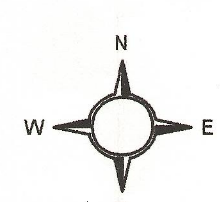
Groundwater analytical results are in Table 10.1.57. Appendix D is a complete analytical report for Zone C, and Appendix H contains detection only summary tables. Groundwater results are compared to the residential RGOs calculated for SWMU 44. Aluminum, arsenic, beryllium, and manganese concentrations for all of Zone C are shown on Figures 10.1.6 through 10.1.9. SVOCs were not detected in groundwater indicating that the levels detected in soil are sufficiently low to protect groundwater. Pesticides/PCBs were not detected in NBC-044-008. Aluminum exceeded its RGO in one monitoring well NBC-044-001. Antimony exceeded its RGO in one monitoring well, NBC-044-007. Arsenic exceeded its risk-based RGO in five monitoring wells and exceeded its hazard-based RGO in seven monitoring wells. All detected concentrations of arsenic were below its MCL of 50 μg/L. Beryllium concentrations did not exceed its risk-based RGO in any monitoring well; however, the hazard-based RGO was exceeded in three monitoring wells. Manganese exceeded its risk-based RGO in six monitoring wells. Nickel did not exceed its risk-based RGO in any monitoring wells.



LEGEND

- Exceeds MCL and Background
- Exceeds MCL
- Exceeds Neither
- Buildings
- Zone C Boundary
- Railroad
- Roads
- Golf Course

Note: All results are in µg/L.



0 150 300 Feet

ZONE C
FINAL RCRA FACILITY
INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 10.1.6
ALUMINUM COMPARISON OF MCL AND
BACKGROUND IN ZONE C
SHALLOW MONITORING WELLS

00072GB4X

LEGEND

- Exceeds MCL and Background
- Exceeds Neither
- Buildings
- Zone C Boundary
- Railroad
- Roads
- Golf Course

Note: All results are in µg/L.

ZONE C
FINAL RCRA FACILITY
INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 10.1.7
ARSENIC COMPARISON OF MCL AND
BACKGROUND IN ZONE C
SHALLOW MONITORING WELLS

LEGEND

- Exceeds MCL and Background
- Exceeds Neither
- No Data Reported
- Buildings
- Zone C Boundary
- Railroad
- Roads
- Golf Course

Note: All results are in µg/L.

N
W E
S

0 150 300 Feet

ZONE C
FINAL RCRA FACILITY
INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 10.1.8
BERYLLIUM COMPARISON OF MCL AND
BACKGROUND IN ZONE C
SHALLOW MONITORING WELLS

LEGEND

- Exceeds MCL and Background
- Exceeds Neither
- Buildings
- Zone C Boundary
- Railroad
- Roads
- Golf Course

Note: All results are in µg/L.

N
W E
S

0 150 300 Feet

ZONE C
FINAL RCRA FACILITY
INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 10.1.9
MANGANESE COMPARISON OF MCL
AND BACKGROUND IN ZONE C
SHALLOW MONITORING WELLS

Table 10.1.57
Comparison of Confirmation Groundwater Samples to Residential RGOs
SWMU 44 – Coal Storage Area

Analyte	Frequency of Detection	Range of Detection	Mean	Residential Risk RGO/ Hazard RGO	Number of Samples Exceeding RGO
Inorganics (mg/kg)					
Aluminum	3/8	28.3 - 20,400	9,402.77	15,600/—	1
Antimony	6/8	1.6 - 35.3	7.63	6/—	1
Arsenic	7/8	3.3 - 34.45	11.99	5/0.4	5/7
Beryllium	3/8	0.25 - 17.5	6.22	78/0.2	0/3
Manganese	8/8	173 - 3,660	1,129	360/—	6
Nickel	8/8	0.7 - 191.0	35.07	310/—	0

Notes:
78/0.2 = 78 μg/L is a hazard-based RGO and 0.2 μg/L is a risk-based RGO.
ND = Not determined

10.1.12 Corrective Measures Considerations for SWMU 44

For SWMU 44, the environmental media which were investigated included surface soil, sediment, shallow groundwater, and surface water. Based on the analytical results and the risk assessment, SWMU 44 is recommended for CMS. COCs were identified for each investigated medium, with the exception of surface water. Aluminum, arsenic, beryllium, thallium, and BaP equivalents were identified as COCs in surface soil and sediment. Thallium was not detected in the confirmation samples after the interim action; therefore, thallium is no longer a COC. Aluminum, antimony, beryllium, lead, manganese, and nickel were identified as COCs in shallow groundwater. Potential corrective measures for the impacted medium and respective COCs are in Table 10.1.58.

Table 10.1.58
Potential Corrective Measures

Medium	Compounds	Potential Corrective Measures
Surface Soil and Sediment	Aluminum, Arsenic, Beryllium, and Benzo(a)pyrene Equivalents	a) No action, intrinsic remediation and monitoring b) Containment/capping c) Ex-situ, chemical, physical and biological treatment d) In-situ, chemical and biological treatment
Shallow Groundwater	Aluminum, Antimony, Arsenic, Beryllium, Manganese	a) No action, intrinsic remediation and monitoring b) Extraction, physical and chemical treatment c) In-situ, physical, and chemical treatment

10.2 SWMU 47 — Former Burning Dump and AOC 516 — Wash Area/Battery Charging

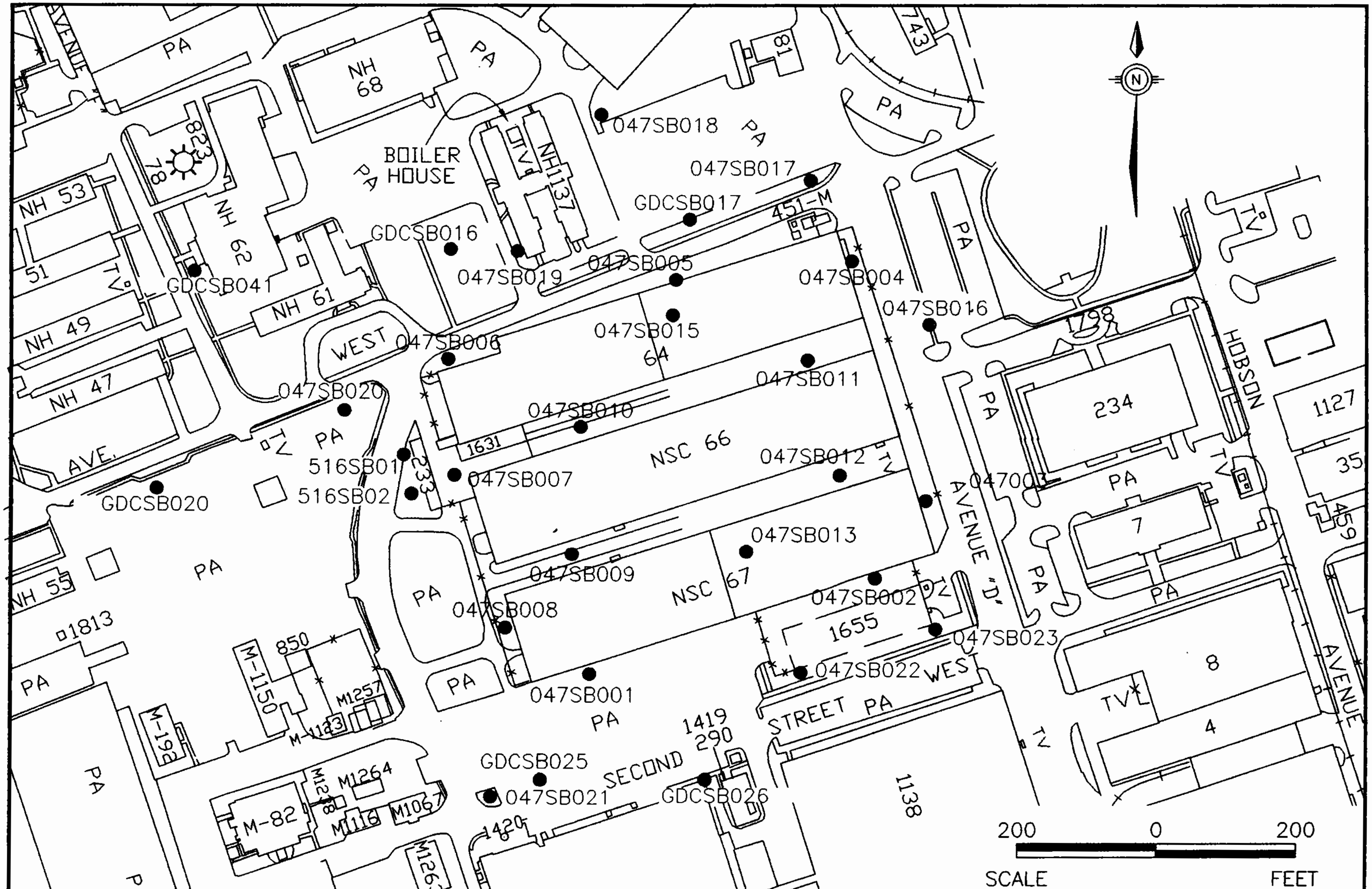
SWMU 47 was a burning dump in the 1920s where various types of wastes (including medical waste) were reportedly incinerated (Figure 10.2.1). More recently, there were reported releases of petroleum onsite. Currently, the site includes Buildings NSC-64, NSC-66, and NSC-67 and the surrounding asphalt and grassy areas. Potential contaminants include residual wastes from incomplete combustion and petroleum hydrocarbons. No previous studies have been completed at SWMU 47.

AOC 516 is just west of SWMU 44 and includes Building 233. This area was used for spray washing vehicles and equipment from 1972 until the 1980s but, more recently, it was used for recharging lead-acid batteries. Potential contaminants include lead and other metals, solvents, battery acids, and petroleum hydrocarbons. No previous studies were completed at AOC 516.

These sites were combined into a single RFI because of their proximity and common potential contaminants. The RFI's objective was to assess potential impacts to soil and groundwater media from reported or suspected releases onsite. The primary focus was placed on groundwater after considering the shallow depth to groundwater and the age of each site.

10.2.1 Soil Sampling and Analysis

Soil was sampled in accordance with the procedures outlined in the *Final Zone C RFI Work Plan* (E/A&H, November 1995) and Section 3 of this report in two rounds. During the first round, 29 soil samples were collected from 16 locations (Figure 10.2.1), 16 from the upper interval and 13 from the lower interval. Each soil sample was analyzed for VOCs, SVOCs, pesticide/PCBs, metals, cyanide, and TPH at DQO Level III. Two duplicate samples were submitted for Appendix IX analyses at DQO Level IV. This includes the parameters listed above as well as herbicides, hexavalent chromium, organophosphorous pesticides, and dioxins. Also, no soil samples were collected at location 047SB014 because of structural barriers within the building and high volume of operations traffic in the area. Lower interval soil samples could not be collected at locations 047SB002 and 047SB0006 because of obstructions. A lower interval soil sample could not be collected at location 047SB0010 because the water table was at 2.5 feet bls. Table 10.2.1 summarizes the first-round soil sampling and analysis.



LEGEND

- ● – 1ST ROUND SOIL SAMPLE LOCATION
- ● – 2ND ROUND SOIL SAMPLE LOCATION

NOTE: 047SB014 NOT INSTALLED

ZONE C
RCRA FACILITY
INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 10.2.1
SWMU 47–FORMER BURNING DUMP
AOC 516–WASH AREA/BATTERY CHARGING
SOIL SAMPLE LOCATIONS

DWG DATE: 10/03/97	DWG NAME: 029ZCFBD

Table 10.2.1
First Round — Soil Sampling and Analysis Summary
SWMU 47 — Former Burning Dump/AOC 516 — Wash Area/Battery Charging

Interval	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
Upper	17	16	Standard Suite[a], TPH	Standard Suite[a], TPH	One boring was not completed, due to obstructions.
Lower	17	13	Standard Suite[a], TPH	Standard Suite[a], TPH	One boring was not completed, due to obstructions. Two lower interval soil samples could not be collected because of obstructions. One lower interval soil sample could not be collected because of a shallow water table (2.5 feet bls).

Note:
[a] = Standard Suite includes VOCs, SVOCs, metals, cyanide, and pesticide/PCBs.

A second round of soil sampling was completed following preliminary review of first-round results including a comparison to the USEPA Region III *Risk-Based Concentration Table*, June 1996. This review indicated that five SVOCs were detected above their respective RBCs at several sampling locations, including those along the site perimeter. Eight supplemental sampling locations were selected to further delineate the extent of SVOCs. Second-round soil samples collected from the upper interval at each of the eight additional locations were submitted for SVOC analysis. Table 10.2.2 summarized the second-round sampling and analysis.

Table 10.2.2
Second Round — Soil Sampling and Analysis Summary
SWMU 47 — Former Burning Dump/AOC 516 — Wash Area/Battery Charging

Interval	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
Upper	0	8	None	SVOC	Added
Lower	0	0	None	None	None

10.2.2 Nature and Extent of Soil Contaminants

Soil analytical results for organics are in Table 10.2.3; results for inorganics are in Table 10.2.4. Appendix D is a complete analytical report for Zone C, and Appendix H contains detection only summary tables.

Table 10.2.3
Organic Compound Analytical Results for Soil
SWMU 47 — Former Burning Dump/AOC 516 — Wash Area/Battery Charging

Compound	Sample Interval	Frequency of Detection	Range of Detection	Mean	RBC[a]	Number of Samples Exceeding RBC
Volatile Organic Compounds (μg/kg) (Upper Interval — 16 Samples plus 2 Duplicates / Lower interval — 13 Samples)						
Acetone	Upper	3/16	11.0 - 76.0	44.667	780,000	0
	Lower	4/13	11.0 - 24.0	17.0	800	0
Semivolatile Organic Compounds (μg/kg) (Upper Interval — 24 Samples plus 3 Duplicates / Lower interval — 13 Samples)						
Acenaphthene	Upper	4/24	45.0 - 340.0	144.75	470,000	0
	Lower	2/13	310.0 - 430.0	370.0	20,000	0
Acenaphthylene	Upper	1/24	210.0	NA	4,700	0
Anthracene	Upper	8/24	47.0 - 1,100.0	255.50	2,300,000	0
	Lower	2/13	71.0 - 880.0	475.50	430,000	0
Benzo(a)anthracene	Upper	15/24	74.0 - 6,100	841.83	880[b]	2
	Lower	3/13	250.0 - 1,600	900.0	700	2
Benzo(a)pyrene	Upper	14/24	72.0 - 4,600	799.71	88[b]	12
	Lower	3/13	240.0 - 1,700	1,046.67	4,000	0
Benzo(b)fluoranthene	Upper	15/24	93.0 - 10,000	1,587.20	880[b]	5
	Lower	3/13	430.0 - 1,700	1,243.33	4,000	0
Benzo(g,h,i)perylene	Upper	10/24	100.0 - 3,000	645.0	230,000	0
	Lower	3/13	150.0 - 600.0	440.0	98,000	0
Benzo(k)fluoranthene	Upper	15/24	100.0 - 11,000	1,721.33	8,800[b]	1
	Lower	3/13	480.0 - 2,500	1,493.33	4,000	0

Table 10.2.3
Organic Compound Analytical Results for Soil
SWMU 47 — Former Burning Dump/AOC 516 — Wash Area/Battery Charging

Compound	Sample Interval	Frequency of Detection	Range of Detection	Mean	RBC[a]	Number of Samples Exceeding RBC
Bis(2-ethylhexyl) phthalate	Upper	2/24	89.0 - 420.0	254.5	46,000	0
Chrysene	Upper	15/24	72.0 - 8,500	1,033.13	8,800[b]	0
	Lower	3/13	380.0 - 1,300	960.0	1,000	2
1-Methylnaphthalene	Upper	3/24	50.0 - 130.0	81.33	310,000	0
	Lower	1/13	140.0	NA	3,000	0
2-Methylnaphthalene	Upper	3/24	42.0 - 100.0	62.0	310,000	0
	Lower	1/13	230.0	NA	3,000	0
Dibenzo(a,h)anthracene	Upper	4/24	65.0 - 1,000	419.25	88.0[b]	2
	Lower	2/13	180.0 - 720.0	450.0	11,000	0
Dibenzo(a,j)acridine	Upper	2/24	100.0 - 190.0	145.0	31,000	0
Dibenzofuran	Upper	3/24	70.0 - 380.0	183.33	31,000	0
	Lower	2/13	69.0 - 200.0	134.5	12,000	0
Diethylphthalate	Upper	1/24	150.0	NA	6,300,000	0
Di-n-butylphthalate	Upper	2/24	86.0 - 135.0	110.5	780,000	0
	Lower	2/13	94.0 - 130.0	112.0	12,000	0
Fluoranthene	Upper	16/24	61.0 - 17,000	1,669.44	310,000	0
	Lower	3/13	390.0 - 2,800	1,263.33	98,000	0
Fluorene	Upper	4/24	58.0 - 650.0	243.0	310,000	0
	Lower	2/13	320.0 - 560.0	440.0	16,000	0
Indeno(1,2,3-cd)pyrene	Upper	10/24	110.0 - 3,200	656.00	880[b]	2
	Lower	3/13	140.0 - 630.0	406.67	35,000	0
Naphthalene	Upper	2/24	150.0 - 430.0	290.0	310,000	0
	Lower	1/13	150.0	NA	3,000	0
Pentachlorophenol	Upper	1/24	660.0	NA	5,300	0
Phenanthrene	Upper	15/24	37.0 - 10,000	1,018.40	230,000	0
	Lower	3/13	320.0 - 3,300	1,426.67	98,000	0

Table 10.2.3
Organic Compound Analytical Results for Soil
SWMU 47 — Former Burning Dump/AOC 516 — Wash Area/Battery Charging

Compound	Sample Interval	Frequency of Detection	Range of Detection	Mean	RBC[a]	Number of Samples Exceeding RBC
Phenol	Upper	1/24	68.0	NA	4,700,000	0
Pyrene	Upper	16/24	59.0 - 12,000	1,352.75	230,000	0
	Lower	4/13	48.0 - 1,900	697.0	140,000	0
BEQ	Upper	15/24	17.77 - 7,648.5	1,163.1	88	14
Pesticide and PCB Compounds (µg/kg) **(Upper Interval — 16 Samples plus 2 Duplicates / Lower interval — 13 Samples)**						
Aldrin	Upper	2/16	0.14 - 0.31	0.225	38	0
	Lower	1/13	0.26	NA	5	0
alpha-BHC	Upper	2/16	0.13 - 0.51	0.32	100	0
beta-BHC	Upper	5/16	0.37 - 64.0	17.55	350	0
	Lower	2/13	18.0 - 40.0	29.0	2	2
4,4-DDD	Upper	3/16	0.40 - 8.20	5.43	2,700	0
	Lower	2/13	0.58 - 0.63	0.61	700	0
4,4-DDE	Upper	5/16	4.0 - 67.0	28.0	1,900	0
	Lower	1/13	1.3	NA	500	0
4,4-DDT	Upper	4/16	1.6 - 46.0	15.58	1,900	0
	Lower	2/13	0.43 - 0.56	0.495	1,000	0
delta-BHC	Upper	3/16	0.46 - 1.5	1.05	350	0
	Lower	1/13	0.32	NA	2	0
Dieldrin	Upper	1/16	1.6	NA	40	0
Endosulfan I	Upper	3/16	0.84 - 4.1	2.18	47,000	0
	Lower	2/13	1.5 - 1.7	1.6	300	0
Endosulfan II	Upper	2/16	0.28 - 3.6	1.94	47,000	0
	Lower	1/13	0.01	NA	300	0
Endosulfan sulfate	Upper	2/16	2.5 - 7.5	5.0	47,000	0
Endrin	Upper	1/16	0.64	NA	2,300	0
	Lower	2/13	0.34 - 0.52	0.43	400	0

Table 10.2.3
Organic Compound Analytical Results for Soil
SWMU 47 — Former Burning Dump/AOC 516 — Wash Area/Battery Charging

Compound	Sample Interval	Frequency of Detection	Range of Detection	Mean	RBC[a]	Number of Samples Exceeding RBC
Endrin aldehyde	Upper	4/16	0.34 - 8.80	3.04	2,300	0
	Lower	2/13	1.4 - 4.5	2.95	400	0
gamma-BHC	Upper	1/16	0.13	NA	490	0
Heptachlor	Upper	3/16	0.27 - 1.9	1.06	140	0
	Lower	1/13	9.3	NA	60	0
Heptachlor epoxide	Upper	5/16	0.17 - 5.5	1.73	70	0
	Lower	2/13	0.34 - 1.10	0.72	60	0
Methoxychlor	Upper	5/16	0.37 - 44.00	20.42	39,000	0
	Lower	2/13	3.7 - 30.0	16.85	62,000	0
Other Organic Compounds						
Total Petroleum Hydrocarbons (mg/kg) **(Upper Interval — 16 Samples plus 2 Duplicates/Lower Interval — 13 Samples)**						
Petroleum Hydrocarbons	Upper	16/16	17.8 - 2,050	316.36	100	9
	Lower	11/13	13.6 - 455	17.29	NA	0
Dioxins (ng/kg) **(Upper Interval — 2 Duplicate Samples Only)**						
1234678-HpCDD	2/2	Upper	4.898 - 21.729	13.31	NA	NA
1234678-HpCDF	2/2	Upper	89.4 - 112.325	100.86	NA	NA
123478-HxCDD	½	Upper	0.486	NA	NA	NA
123478-HxCDF	2/2	Upper	8.81 - 11.416	10.11	NA	NA
123678-HxCDD	½	Upper	0.663	NA	NA	NA
123678-HxCDF	2/2	Upper	2.493 - 5.784	4.14	NA	NA
123789-HxCDD	½	Upper	0.727	NA	NA	NA
123789-HxCDF	½	Upper	0.71	NA	NA	NA
234678-HxCDF	2/2	Upper	.711 - 1.687	1.199	NA	NA
OCDD	2/2	Upper	79.6 - 246.65	163.17	NA	NA

Table 10.2.3
Organic Compound Analytical Results for Soil
SWMU 47 — Former Burning Dump/AOC 516 — Wash Area/Battery Charging

Compound	Sample Interval	Frequency of Detection	Range of Detection	Mean	RBC[a]	Number of Samples Exceeding RBC
OCDF	2/2	Upper	222.1 - 291.7	256.9	NA	NA
TCDD TEQ	2/2	Upper	2.59 - 3.89	3.24	1,000	0

Notes:
[a] = Noncarcinogenic RBCs were adjusted to equateto a hazard quotient of 0.1.
[b] = These compounds are cPAHs and were multiplied by the appropriate BEF for comparison as BEQs.
All results are in micrograms per kilogram (μg/kg), except for Total Petroleum Hydrocarbons, which are in milligrams per kilogram (mg/kg) and dioxins which are in nanograms per kilogram (ng/kg).

Table 10.2.4
Inorganics Analytical Results for Soil
SWMU 47 — Former Burning Dump/AOC 516 — Wash Area/Battery Charging

Analyte	Sample Interval	Frequency of Detection	Range of Detection (mg/kg)	Mean (mg/kg)	Reference Conc.	Number of Samples Exceeding Reference
Aluminum	Upper	16/16	3,045 - 13,900	6,413.10	9,990	2
	Lower	13/13	1,030 - 22,300	6,268.46	23,700	0
Antimony	Upper	4/16	0.40 - 1.90	1.02	0.55	2
	Lower	6/13	0.22 - 1.40	0.73	0.92	1
Arsenic	Upper	9/16	0.38 - 27.8	6.16	14.2	1
	Lower	7/13	0.47 - 12.2	4.37	14.1	0
Barium	Upper	16/16	7.4 - 170.0	32.69	77.2	1
	Lower	13/13	5.2 - 273.0	44.35	68.5	2
Beryllium	Upper	3/16	0.37 - 0.50	0.42	ND	3
	Lower	2/13	0.62 - 1.10	0.86	0.98	1
Cadmium	Upper	1/16	2.9	NA	0.65	1
	Lower	1/13	2.8	NA	0.28	1
Calcium	Upper	16/16	298 - 63,100	12,152.81	NA	0
	Lower	13/13	115 - 61,800	9,262.85	NA	0
Chromium	Upper	16/16	2.8 - 44.6	14.30	26.4	3
	Lower	13/13	1.2 - 37.7	11.74	12.5	5

Table 10.2.4
Inorganics Analytical Results for Soil
SWMU 47 — Former Burning Dump/AOC 516 — Wash Area/Battery Charging

Analyte	Sample Interval	Frequency of Detection	Range of Detection (mg/kg)	Mean (mg/kg)	Reference Conc.	Number of Samples Exceeding Reference
Cobalt	Upper	13/16	0.57 - 9.70	2.97	3.22	4
	Lower	11/13	0.13 - 7.20	2.03	7.1	1
Copper	Upper	16/16	1.3 - 416.0	43.38	34.7	3
	Lower	12/13	0.9 - 1,650	178.38	42.2	2
Iron	Upper	16/16	924 - 63,900	8,115.88	NA	0
	Lower	13/13	678 - 45,200	8,434.46	NA	0
Lead	Upper	16/16	3.3 - 1,120	112.07	330	1
	Lower	13/13	2.1 - 1,190	124.91	73.2	2
Magnesium	Upper	16/16	134.0 - 3,650	813.03	NA	0
	Lower	13/13	41.1 - 4,630	1,027.47	NA	0
Manganese	Upper	16/16	5.3 - 331.0	55.08	92.5	2
	Lower	13/13	3.1 - 276.0	62.38	106	2
Mercury	Upper	5/16	0.13 - 2.20	0.60	0.24	2
	Lower	3/13	0.52 - 8.2	3.11	0.30	3
Nickel	Upper	16/16	0.73 - 26.50	6.36	12.3	2
	Lower	13/13	0.38 - 60.70	8.90	16.7	1
Potassium	Upper	15/16	81.3 - 1,010	348.63	NA	0
	Lower	12/13	85.8 - 2,120	452.01	NA	0
Selenium	Upper	9/16	0.47 - 2.40	0.96	1.44	2
	Lower	7/13	0.58 - 2.50	1.39	2.90	0
Sodium	Upper	5/16	295.5 - 1,000	638.70	NA	0
	Lower	4/13	283.0 - 1,020	546.25	NA	0
Thallium	Upper	1/16	2.1	N	ND	1
	Lower	1/13	1.8	NA	ND	1
Tin	Upper	11/16	0.94 - 46.70	9.25	2.95	4
	Lower	11/13	0.67 - 365.0	39.22	2.37	2

Table 10.2.4
Inorganics Analytical Results for Soil
SWMU 47 — Former Burning Dump/AOC 516 — Wash Area/Battery Charging

Analyte	Sample Interval	Frequency of Detection	Range of Detection (mg/kg)	Mean (mg/kg)	Reference Conc.	Number of Samples Exceeding Reference
Vanadium	Upper	16/16	1.7 - 44.1	11.67	23.4	2
	Lower	13/13	1.1 - 78.8	17.29	56.9	2
Zinc	Upper	16/16	5.2 - 1,100	140.61	159	3
	Lower	13/13	2.5 - 1,320	141.41	243	1

Volatile Organic Compounds in Soil

Acetone was the only VOC detected in soil samples. It was detected at three locations in the upper interval and at four locations in the lower interval. Acetone did not exceed its RBC at any location.

Semivolatile Organic Compounds in Soil

Twenty-five SVOCs were detected at SWMU 47/AOC 516. Six compounds exceeded RBCs in the upper interval; all of the SVOCs that exceeded their RBCs are cPAHs. Two compounds exceeded their SSLs in the lower interval. The BEQ calculated exceeded the RBC of 88.0 μg/kg for BaP at 14 locations in the upper interval. The highest BEQs were at locations 047SB005 (upper) and 047SB016 (upper). Second-round analytical results indicated that SVOCs were present at additional sampling sites 047SB016, 047SB017, 047SB018, and 047SB019 (Figure 10.2.1).

Pesticides and PCBs in Soil

Seventeen pesticides were detected in the upper sample interval from 12 sample locations; 13 pesticides were detected in the lower interval from four locations. However, no pesticide exceeded its respective RBCs in surface soil or SSLs in subsurface soil. No PCBs were detected in the soil samples collected at SWMU 44.

Other Organic Compounds in Soil

Other organic compounds include the Appendix IX compound groups that are not part of the standard analytical suite, including herbicides, organophosphorous pesticides, and dioxins.

Petroleum hydrocarbons were detected at all upper interval locations and at 11 of 13 lower interval locations. The TPH screening level of 100 mg/kg was exceeded at nine upper interval locations.

No herbicides were detected in soil samples collected at SWMU 47. No organophosphorous pesticides were detected in soil samples collected at SWMU 47.

Dioxins were detected in both samples submitted for analysis — 047CB00401 and 47CB00901 with TEQs of 2.59 ng/kg and 3.89 ng/kg, respectively. The RBC for TCDD equivalents is 1,000 ng/kg.

Inorganic Elements in Soil

Twenty-three analytes were detected in soil samples collected from SWMU 47 and AOC 516. Eighteen exceeded their respective reference concentrations in samples from the upper interval. The greatest number of exceedances (four) in the upper interval was for cobalt and tin. Fifteen analytes detected in the lower interval were above their respective reference concentrations. Of these, chromium had the greatest number of exceedances at five. Table 10.2.4 summarizes the inorganic analytes detected in soil samples from SWMU 47 and AOC 516.

No cyanide was detected in soil samples from SWMU 47/AOC 516. Hexavalent chromium was detected in the upper interval at 047CB009 at 0.259 mg/kg.

10.2.3 Groundwater Sampling and Analysis

Fourteen monitoring wells were installed and sampled to assess groundwater quality at SWMU 47 (Figure 10.2.2). No monitoring well was installed at location 0477MW014 because of structural barriers within the building and the high volume of operations traffic in the area. Groundwater samples were submitted for analysis of VOCs, SVOCs, pesticides/PCBs, TPH (GRO and DRO), metals, and cyanide at DQO Level III. Duplicate groundwater samples were submitted for Appendix IX analyses at DQO Level IV, which includes the parameters listed above and herbicides, hexavalent chromium, organophosphorous pesticides, and dioxins. Detected concentrations in groundwater will be further evaluated based on additional groundwater data collected during the subsequent three quarters of sampling. The data are discussed in the Section 11. The data are discussed in the Section 11. Table 10.2.5 summarizes the initial round of groundwater sampling and analysis.

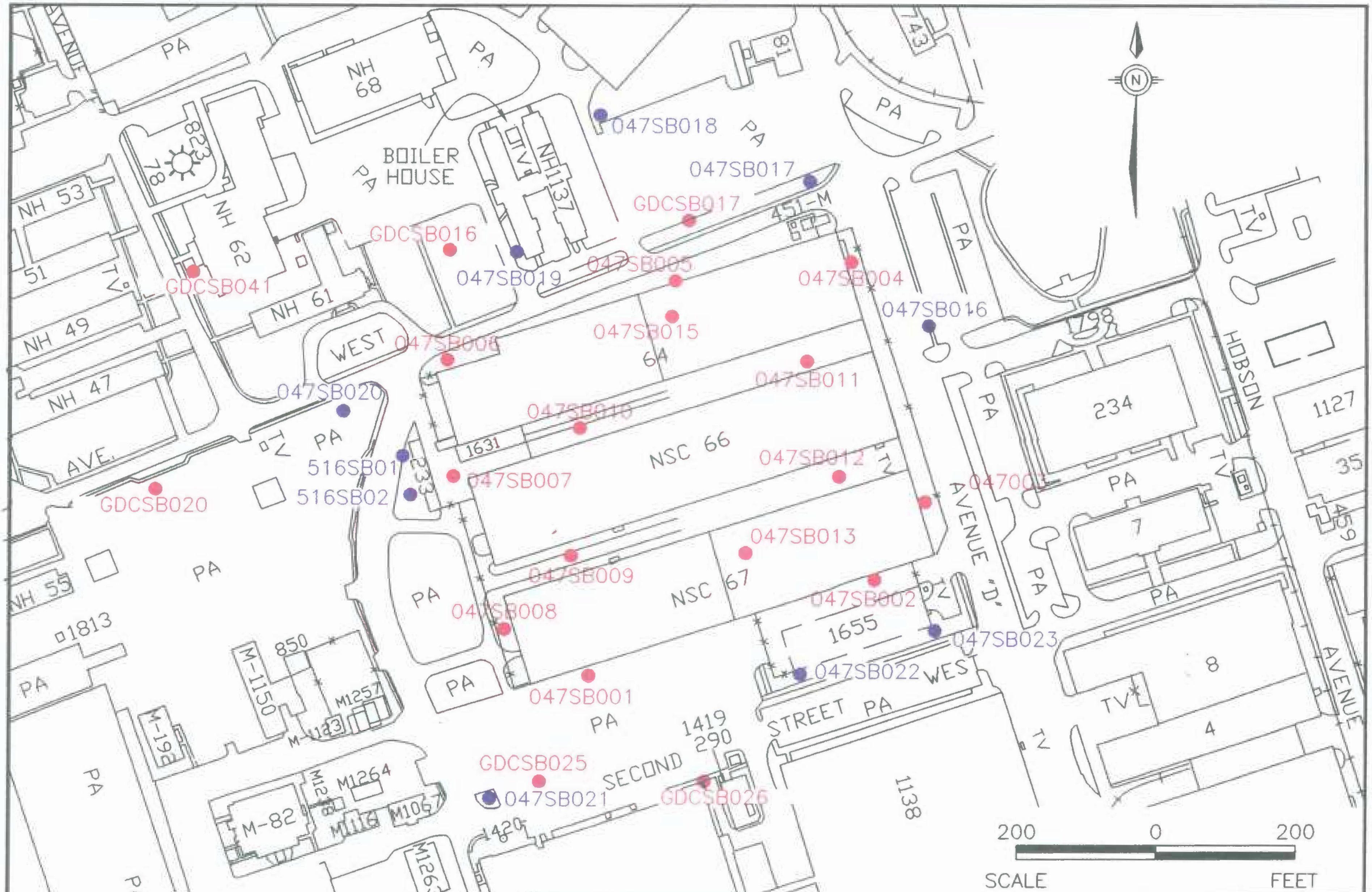
Table 10.2.5
Groundwater Sampling and Analysis
SWMU 47 — Former Burning Dump/AOC 516 — Wash Area/Battery Charging

Interval	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
Shallow	15	14	Standard Suite[a], TPH	Standard Suite[a], TPH	One well was not installed due to obstruction.

Note:
[a] = Standard suite includes VOCs, SVOCs, metals, cyanide, and pesticide/PCBs.

10.2.4 Nature and Extent of Groundwater Contamination

Groundwater analytical results for organics are in Table 10.2.6; for inorganics they are in Table 10.2.7. Appendix D contains the analytical data for Zone C, and Appendix H contains detection only summary tables.



LEGEND

- ● – 1ST ROUND SOIL SAMPLE LOCATION
- ● – 2ND ROUND SOIL SAMPLE LOCATION

NOTE: 047SB014 NOT INSTALLED

ZONE C
RCRA FACILITY
INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 10.2.1
SWMU 47–FORMER BURNING DUMP
AOC 516–WASH AREA/BATTERY CHARGING
SOIL SAMPLE LOCATIONS

DWG DATE: 10/03/97 | DWG NAME: 029ZCFBD

Table 10.2.6
Organic Compound Analytical Results for Shallow Groundwater
SWMU 47 — Former Burning Dump/AOC 516 — Wash Area/Battery Charging

Compound	Frequency of Detection	Range of Detection	Mean	Tap Water[a] RBC	Number of Samples Exceeding RBC
Volatile Organic Compounds (μg/L)					
Carbon disulfide	2/14	2.0 - 7.0	4.5	1,000	0
Semivolatile Organic Compounds (μg/L)					
Acenaphthene	2/14	1.0	1.0	220	0
Butylbenzyphthalate	3/14	4.0	4.0	730	0
3,3-Dimethylbenzidine	1/14	100.0	NA	0.0073	1
Diethylphthalate	1/14	1.0	NA	29,000	0
Fluoranthene	1/14	3.0	NA	150	0
Phenanthrene	1/14	1.0	NA	110	0
Pyrene	1/14	3.0	NA	1,100	0
Pesticides and PCBs (μg/L)					
Heptachlor epoxide	1/14	0.035	NA	0.0023	1
Total Petroleum Hydrocarbons (mg/L)					
DRO	1/14	0.13	NA	NA	NA
GRO	1/14	0.66	NA	NA	NA
Dioxins (pg/L)					
OCDD	1/1	17.677	NA	NA	NA

Table 10.2.6
Organic Compound Analytical Results for Shallow Groundwater
SWMU 47 — Former Burning Dump/AOC 516 — Wash Area/Battery Charging

Compound	Frequency of Detection	Range of Detection	Mean	Tap Water[a] RBC	Number of Samples Exceeding RBC
123789-HxCDF	1/1	2.815	NA	NA	NA
OCDF	1/1	1.853	NA	NA	NA

Notes:
[a] = Noncarcinogenic RBCs were adjusted to equate to an HQ of 0.1.
[b] = These compounds are cPAHs and were multiplied by the appropriate BEF for comparison as BEQs.
All results are in micrograms per liter (μg/L), except for dioxins which are in picograms per liter (pg/L) and Total Petroleum Hydrocarbons which are in milligrams per liter (mg/L).

Table 10.2.7
Inorganic Analytical Results for Groundwater
SWMU 47 — Former Burning Dump/AOC 516 — Wash Area/Battery Charging

Analyte	Frequency of Detection	Range of Detection (μg/L)	Mean (μg/L)	Reference Conc.	Number of Samples Exceeding Reference
Aluminum	7/14	275.0 - 978.0	498.00	410	4
Antimony	2/14	3.1 - 53.1	28.10	ND	2
Arsenic	5/14	3.9 - 46.3	14.52	6.07	4
Barium	6/14	13.4 - 93.4	43.88	16.7	5
Calcium	14/14	6,780 - 156,000	45,048.50	NA	0
Chromium	8/14	0.93 - 3.50	1.62	1.99	2
Cobalt	1/14	1.3	NA	1.33	0
Copper	4/14	2.1 - 4.2	3.05	1.90	4
Iron	14/14	182 - 25,700	5,600.61	NA	0
Lead	5/14	4.6 - 467.0	98.02	3.27	5
Magnesium	14/14	1,440 - 24,100	7,491.43	NA	0

Table 10.2.7
Inorganic Analytical Results for Groundwater
SWMU 47 — Former Burning Dump/AOC 516 — Wash Area/Battery Charging

Analyte	Frequency of Detection	Range of Detection (μg/L)	Mean (μg/L)	Reference Conc.	Number of Samples Exceeding Reference
Manganese	14/14	23.7 - 598.0	136.08	608	0
Nickel	3/14	2.3 - 4.4	3.27	3.59	1
Potassium	14/14	1,230 - 12,700	4,498.57	NA	0
Selenium	1/14	4.5	NA	ND	1
Silver	1/14	0.62	NA	1.26	0
Sodium	14/14	5,290 - 42,400	22,089.20	NA	0
Tin	2/14	9.7 - 77.6	43.65	ND	2
Vanadium	11/14	0.48 - 7.30	2.11	1.96	2
Zinc	9/14	14.8 - 106.0	54.78	13.2	9

Volatile Organic Compounds in Groundwater

Only one VOC was detected in groundwater at SWMU 47/AOC 516. Carbon disulfide was detected below its RBC of 1,000 μg/L.

Semivolatile Organic Compounds in Groundwater

Seven SVOCs were detected in groundwater samples at SWMU 47/AOC 516. Only one compound, dimethylbenzidine, exceeded its tap water RBC of 0.0073 μg/L. This compound was detected in only one well, 047MW005. It was detected at 100.0 μg/L.

Pesticides and PCBs in Groundwater

One pesticide, heptachlor epoxide, was detected below its RBC in groundwater samples from SWMU 47/AOC 516.

Other Organics in Groundwater

Other organic compounds include TPH analysis and the Appendix IX compound groups that are not part of the standard analytical suite, including herbicides, organophosphorous pesticides, and dioxins.

Herbicides and organophosphorous pesticides were detected in groundwater samples submitted for analysis at SWMU 47. Three dioxins were detected in the duplicate soil sample submitted for Appendix IX analyses.

TPH-GRO was detected in one groundwater sample at 0.66 mg/L. TPH-DRO was detected in one well, 047MW010. It was detected at 0.13 mg/L.

Inorganic Elements in Groundwater

Twenty inorganic analytes were detected in groundwater samples from SWMU 47/AOC 516. Twelve analytes exceeded their respective reference concentrations: aluminum, antimony, arsenic, barium, chromium, copper, lead, nickel, selenium, tin, vanadium, and zinc. Zinc had the greatest number of exceedances with nine out of nine detections. Hexavalent chromium was not detected. Table 10.2.7 summarizes of the inorganic analytical results for groundwater for SWMU 47/AOC 516.

10.2.5 Fate and Transport Assessment

SWMU 47 formerly supported a waste incinerator and is currently the site of Buildings NSC-64, NSC-66, and NSC-67. The area surrounding these buildings is covered by asphalt and grass.

AOC 516 was used for spray washing vehicles and more recently was used for recharging lead-acid batteries. Building 233 is located on this site. These two sites are combined for the evaluation of fate and transport based on their proximity. Environmental media sampled as part of the SWMU 47 investigation include surface soil, subsurface soil, and groundwater. Potential migration pathways for SWMU 47 include constituents leaching from soil to groundwater, groundwater migration to surface water, and emission of volatile constituents from surface soil to air.

10.2.5.1 Soil to Groundwater Cross Media Transport

Table 10.2.8 compares the maximum detected concentrations of chemicals in soil to the greater of the groundwater protection SSLs or background reference concentrations. Five organic compounds (benzo(a)anthracene, benzo(f)fluoranthene, alpha-BHC, beta-BHC, and pentachlorophenol) and five inorganic chemicals (chromium, cobalt, copper, mercury, and tin) were detected above SSLs in soil but were not found above reference or risk-based concentrations in shallow groundwater in first-quarter samples. A review of subsequent quarterly results confirmed their absence at significant levels. As a result, existing soil concentrations are considered protective of the water table aquifer.

Lead was detected above reference concentrations exclusively in boring 047SB007. The closest monitoring well, 047007, produced samples with nondetect lead for four consecutive quarters. Monitoring well 047001 produced an exceedingly high lead result first quarter (467 μg/L). Subsequent quarterly results were nondetect indicating the initial data gave an erroneous account of groundwater quality. A single exceedance of the lead TTAL (15 μg/L) was noted in the second quarter samples from 047010, but following quarterly results were below the groundwater standard.

Table 10.2.8
Chemicals Detected in Surface Soil, Subsurface Soil and Groundwater
Comparison to Groundwater Protection SSLs, Tap Water RBCs and Background UTLs
NAVBASE-Charleston, Zone C, SWMU 47 and AOC 516
Charleston, South Carolina

Parameter	Surface Soil Maximum Conc.	Subsurface Soil Maximum Conc.	Ground Water Protection SSL or UTL *	Soil Units	Ground-water Maximum Conc.	Tap Water RBC or UTL *	Water Units	Soil Conc. Exceeds SSL or UTL	Ground-water Conc. Exceeds RBC or UTL
Acenaphthene	340	430	57000	UG/KG	1	220	UG/L	NO	NO
Acenaphthylene	210	ND	11000	UG/KG	ND	220	UG/L	NO	NO
Acetone	76	24	1600	UG/KG	ND	370	UG/L	NO	NO
Aldrin	0.31	0.26	500	UG/KG	ND	0.004	UG/L	NO	NO
Aluminum	13900	22300	23700	MG/KG	978	3700	UG/L	NO	NO
Anthracene	1100	880	1200000	UG/KG	ND	1100	UG/L	NO	NO
Antimony	1.9	1.4	5	MG/KG	53.1	1.5	UG/L	NO	YES
Arsenic	27.8	12.2	29	MG/KG	46.3	6.07	UG/L	NO	YES
Barium	170	273	1600	MG/KG	93.4	260	UG/L	NO	NO
Benzo(ghi)perylene	3000	600	46000	UG/KG	ND	150	UG/L	NO	NO
Benzo(a)pyrene Equivalents									
Benzo(a)pyrene	4600	1700	8000	UG/KG	ND	0.0092	UG/L	NO	NO
Benzo(a)anthracene	6100	1600	2000	UG/KG	ND	0.092	UG/L	YES	NO
Benzo(b)fluoranthene	10000	1700	5000	UG/KG	ND	0.092	UG/L	YES	NO
Benzo(k)fluoranthene	11000	2500	49000	UG/KG	ND	0.92	UG/L	NO	NO
Chrysene	8500	1300	160000	UG/KG	ND	9.2	UG/L	NO	NO
Dibenzo(a,h)anthracene	1000	720	2000	UG/KG	ND	0.0092	UG/L	NO	NO
Indeno(1,2,3-cd)perylene	3200	630	14000	UG/KG	ND	0.092	UG/L	NO	NO
Beryllium	0.5	1.1	63	MG/KG	ND	0.33	UG/L	NO	NO
alpha-BHC	0.51	ND	0.5	UG/KG	ND	0.011	UG/L	YES	NO
beta-BHC	64	40	3	UG/KG	ND	0.037	UG/L	YES	NO
delta-BHC	1.5	0.32	3	UG/KG	ND	0.037	UG/L	NO	NO
gamma-BHC (Lindane)	0.13	ND	9	UG/KG	ND	0.052	UG/L	NO	NO
Butylbenzylphthalate	ND	ND	930000	UG/KG	4	730	UG/L	NO	NO
Cadmium	2.9	2.8	8	MG/KG	ND	1.8	UG/L	NO	NO
Carbon disulfide	ND	ND	3200	UG/KG	7	2.1	UG/L	NO	YES
Chromium	44.6	37.7	38	MG/KG	3.5	18	UG/L	YES	NO
Cobalt	9.7	7.2	7.1	MG/KG	1.3	220	UG/L	YES	NO
Copper	416	1650	42.2	MG/KG	4.2	150	UG/L	YES	NO
4,4'-DDD	8.2	0.63	16000	UG/KG	ND	0.28	UG/L	NO	NO
4,4'-DDE	67	1.3	54000	UG/KG	ND	0.2	UG/L	NO	NO
4,4'-DDT	46	0.56	32000	UG/KG	ND	0.2	UG/L	NO	NO
Dibenzo(a,j)anthracene	190	ND	2000	UG/KG	ND	NA	UG/L	NO	NO
Dibenzofuran	380	200	12000	UG/KG	ND	15	UG/L	NO	NO
Di-n-butylphthalate	135	130	2300000	UG/KG	ND	370	UG/L	NO	NO
Dieldrin	1.6	ND	4	UG/KG	ND	0.0042	UG/L	NO	NO
Diethylphthalate	150	ND	47000	UG/KG	1	2900	UG/L	NO	NO
3,3'-Dimethylbenzidine	ND	ND	0.2	UG/KG	100	0.0073	UG/L	NO	YES
Dioxin (TCDD TEQ)	3.89	ND	4000	PG/G	ND	0.5	PG/L	NO	NO
Endosulfan	11.1	1.5	1800	UG/KG	ND	22	UG/L	NO	NO
Endrin	0.64	0.52	1000	UG/KG	ND	1.1	UG/L	NO	NO
Endrin aldehyde	8.8	4.5	1000	UG/KG	ND	1.1	UG/L	NO	NO
bis(2-Ethylhexyl)phthalate	420	ND	3600000	UG/KG	ND	4.8	UG/L	NO	NO
Fluoranthene	17000	2800	430000	UG/KG	3	150	UG/L	NO	NO
Fluorene	650	560	56000	UG/KG	ND	150	UG/L	NO	NO
Heptachlor	6.5	10.4	23000	UG/KG	ND	0.0023	UG/L	NO	NO
Lead	1120	1190	330	MG/KG	467	15	UG/L	YES	YES
Manganese	331	276	106	MG/KG	598	608	UG/L	YES	NO
Mercury	2.2	8.2	0.3	MG/KG	ND	1.1	UG/L	YES	NO

Table 10.2.8
Chemicals Detected in Surface Soil, Subsurface Soil and Groundwater
Comparison to Groundwater Protection SSLs, Tap Water RBCs and Background UTLs
NAVBASE-Charleston, Zone C, SWMU 47 and AOC 516
Charleston, South Carolina

Parameter	Surface Soil Maximum Conc.	Subsurface Soil Maximum Conc.	Ground Water Protection SSL or UTL *	Soil Units	Ground-water Maximum Conc.	Tap Water RBC or UTL *	Water Units	Soil Conc. Exceeds SSL or UTL	Ground-water Conc. Exceeds RBC or UTL
Methoxychlor	44	30	160000	UG/KG	ND	18	UG/L	NO	NO
1-Methylnaphthalene	130	140	51000	UG/KG	ND	150	UG/L	NO	NO
2-Methylnaphthalene	100	230	51000	UG/KG	ND	150	UG/L	NO	NO
Naphthalene	430	150	8400	UG/KG	ND	150	UG/L	NO	NO
Nickel	25.6	60.7	130	MG/KG	4.4	73	UG/L	NO	NO
Pentachlorophenol	660	ND	30	UG/KG	ND	0.56	UG/L	YES	NO
Phenanthrene	10000	3300	100000000	UG/KG	1	150	UG/L	NO	NO
Phenol	68	ND	10000	UG/KG	ND	2200	UG/L	NO	NO
Pyrene	12000	1900	420000	UG/KG	3	110	UG/L	NO	NO
Selenium	2.4	2.5	5	MG/KG	4.5	18	UG/L	NO	NO
Silver	ND	ND	34	MG/KG	0.62	18	UG/L	NO	NO
Tin	46.7	365	2.95	MG/KG	77.6	2200	UG/L	YES	NO
Thallium	2.1	1.8	0.7	MG/KG	ND	0.29	UG/L	YES	NO
Total Petroleum Hydrocarbon	2050	266	NA	MG/KG	0.66	NA	UG/L	YES	YES
Vanadium	44.1	78.8	600	MG/KG	7.3	26	UG/L	NO	NO
Zinc	1100	1320	1200	MG/KG	106	1100	UG/L	YES	NO

* - See Table 6-2
NA - Not available
ND - Not detected
SSL - Groundwater protection soil screening level
UTL - Grid-based background upper tolerance limit
RBC - Tap water risk-based concentration
MG/KG - Milligram per kilogram
UG/KG - Micrograms per kilogram
UG/L - Micrograms per liter

Manganese was detected above the reference concentration in samples from soil borings 047007, 047008, and 516001. Groundwater reference concentration exceedances were reported in shallow wells 047011 and 047015, which are not proximate to elevated soil results. In no instance did groundwater concentrations exceed background by greater than 5%.

Thallium was detected exclusively in soil samples from boring 047007. The mean soil thallium concentration is below the SSL and the maximum source area is less than 0.5 acres. Sporadic shallow groundwater hits were reported in second, third, and fourth-quarter samples from monitoring wells 047002, 047005, 047007, and 047015. In no instance were thallium results reproducible between quarterly events.

Based on the preceding analysis, existing soil quality is generally considered protective of shallow groundwater. This conclusion is by and large corroborated by groundwater results. The exception is thallium which has not followed a pattern relative to soil source or consistent groundwater detection.

10.2.5.2 Groundwater-to-Surface Water Cross-Media Transport

Aluminum, antimony, arsenic, carbon disulfide, 3,3'-dimethylbenzidine, lead, and manganese were detected in SWMU 47 shallow groundwater above tapwater RBCs or background reference concentrations in first-quarter samples. Thallium was also detected in second through fourth quarter samples. 3,3'-dimethylbenzidine was not detected in subsequent quarterly samples. Carbon disulfide was not detected above its tap water RBC in second, third, or fourth-quarter groundwater samples. Exceedances occurring in shallow groundwater are isolated to one or two monitoring wells. Antimony, arsenic, lead, and manganese will not migrate with the groundwater based on a tendency to adsorb to the soil matrix.

To focus on the ability of these constituents to migrate to adjacent surface water bodies, a travel-time analysis was performed. The closest downgradient surface water body to SWMU 47 is the Cooper River. Groundwater travel time to the Cooper River is estimated to be 126 years. Carbon disulfide is the most mobile compound detected in SWMU 47 shallow groundwater. Based on a K_{oc} of 6.18 and Zone C soil parameters (total porosity of 35%, a total organic carbon of 0.006 and a bulk density of 1.67 kg/m^3) the retardation factor for carbon disulfide is 1.2. This increases the travel time for carbon disulfide to surface water via groundwater migration to 148 years. Although each of the identified groundwater contaminants could reach the Cooper River, travel time analysis, as well as the limited impacts, suggest surface water is not threatened by this pathway.

10.2.5.3 Soil-to-Air Cross Media Transport

Table 10.2.9 lists the volatile organic compounds detected in surface soil samples collected at SWMU 47, along with corresponding soil-to-air volatilization screening levels. The maximum surface soil concentration of no volatile organic compound exceeded its corresponding soil-to-air volatilization screening level. As a result, the soil-to-air migration pathway is not expected to be significant at SWMU 47.

10.2.5.4 Fate and Transport Summary

Table 10.2.10 summarizes the constituents and migration pathways significant at SWMU 47.

10.2.6 Human Health Risk Assessment

10.2.6.1 Site Background and Investigative Approach

SWMU 47 (including AOC 516) was investigated to assess soil and groundwater potentially affected by past site activities. SWMU 47 is a former burning dump used during the 1920s. Currently, it is an asphalt and grassy area on which Buildings NSC-64, NSC-66, and NSC-67 are located. Petroleum product spills have been reported at these buildings in recent years.

TABLE 10.2.9
Soil-to-Air Volatilization Screening Analysis
NAVBASE - Charleston Zone I, SWMU 47 and AOC 516
Charleston, South Carolina

VOCs	Maximum Concentratio in Surface Soil	Soil to Air SSL *	Units	Exceeds SSL
Acetone	0.076	100000	MG/KG	NO

* - Soil-to-air RBCs were obtained from USEPA Soil Screening Guidance: Technical Background Document, May 1996.

⁻˙ble 10.2.10
nificant Migration Pathways
ɴAVBASE-Charleston, Zone C, SWMU 47 and AOC 516
Charleston, South Carolina

	Soil to Groundwater	Groundwater to Surface Water
Carbon disulfide		X*
Thallium	X a	

Notes:
* Carbon disulfide has an estimated travel time to the Copper River of 148 years
(a) A definitive correlation could not be established between observed soil and groundwater thallium results.

AOC 516 is the former wash area in Building 233, used for spray washing vehicles and equipment from 1972 until the 1980s. More recently, it was the site of a lead-acid battery charging facility.

Twenty-five soil samples were collected from the upper interval. Table 10.2.11 lists the analytical methods used for the corresponding samples. The number of soil samples differs for various groups of analytes because specific groups of analytes were targeted at certain sample locations and/or sampling phases. Groundwater samples collected from 14 shallow monitoring wells were analyzed for a list of parameters similar to that for soil samples. Groundwater analytes are listed in Table 10.2.12. Three subsequent rounds of groundwater data were collected after the submission of the draft RFI report. These data have been used to perform qualitative and quantitative trend analyses as part of the exposure assessment. Where applicable, quarterly data was also used to eliminate parameters from formal assessment as a means of identifying anomalous data.

10.2.6.2 COPC Identification

Soil

Based on the screening comparisons described in Section 7 of this RFI and presented in Table 10.2.13, this HHRA focuses on the following COPCs: aluminum, arsenic, beryllium, BEQs, chromium, copper, lead, manganese, and thallium. Wilcoxon rank sum test analyses did not identify any inorganic parameters that had been screened out on the basis of reference concentration and RBC comparisons. Chromium was initially identified as a COPC based on screening versus the residential RBC for hexavalent chromium. Hexavalent chromium analysis was performed on representative soil samples with results indicating that less than 5% of the total exists in this valence state. The maximum chromium concentration (44.6 mg/kg) is well below the RBC for the predominant trivalent chromium (7,800 mg/kg). As a result, chromium was not retained as a COPC for formal assessment. TPH were identified in all 16 samples analyzed

Table 10.2.11
Methods Run at SWMU 47 and AOC 516
Surface Soil

Site	Location	Metal	SVOA	VOA	Cn	Hexa	Diox	Oppe	Herb	Pest	Tph	Otin	Eng
047	B001	Y	Y	Y	Y					Y	IR		
047	B002	Y	Y	Y	Y					Y	IR		
047	B003	Y	Y	Y	Y					Y	IR		
047	B004	D	D	D	D	Y	Y	Y	Y	D	IR		
047	B005	Y	Y	Y	Y					Y	IR		Y
047	B006	Y	Y	Y	Y					Y	IR		
047	B007	Y	Y	Y	Y					Y	IR		
047	B008	Y	Y	Y	Y					Y	IR		
047	B009	D	D	D	D	Y	Y	Y	Y	D	IR		
047	B010	Y	Y	Y	Y					Y	IR		
047	B011	Y	Y	Y	Y					Y	IR		
047	B012	Y	Y	Y	Y					Y	IR		
047	B013	Y	Y	Y	Y					Y	IR		
047	B015	Y	Y	Y	Y					Y	IR		
047	B016		D										
047	B017		Y										
047	B018		Y										
047	B019		D										
047	B020		Y										
047	B021		Y										
047	B022		Y										
047	B023		Y										
516	B001	Y	Y	Y	Y					Y	IR		
516	B002	Y	Y	Y	Y					Y	IR		

METHODS:

- Metal: TAL (Target Analyte List) Metals plus tin: Methods: 6000/7000 Series
- VOA: Volatile Organic Analysis: Method 8240
- SVOA: Semi-volatile Organic Analysis: Method 8270
- Cn: Cyanide (Soil: Method 9010, Water: Method 9012)
- Hexa: Hexavalent Chromium: Method 7195
- Diox: Dioxins
- Oppe: Organophosphate Pesticides: Method 8140
- Herb: Chlorinated Herbicides: Method 8150
- Pest: Chlorinated Pesticides: Method 8080
- Tph: Total Petroleum Hydrocarbons
- Otin: Organotin
- Eng: Engineering Parameters

KEY:

- Y: Analyzed for standard list
- D: Duplicate Analysis
- IR: Method 4181
- DR: Extraction Method 3550, GC Method 8100
- GR: Extraction Method 5030, GC Method 8015

Blank value indicates this method of analysis was not performed

Table 10.2.12
Methods Run at SWMU 47 and AOC 516
Shallow Groundwater, Sampling Round 1

Site	Location	Metal	SVOA	VOA	Cn	Hexa	Diox	Oppe	Herb	Pest	Tph	Otin	Eng
047	W001	Y	Y	Y	Y					Y	GR, DR		
047	W002	Y	Y	Y	Y					Y	GR, DR		
047	W003	Y	Y	Y	Y					Y	GR, DR		
047	W004	Y	Y	Y	Y					Y	GR, DR		
047	W005	D	D	D	D			Y	Y	D	GR, DR		
047	W006	Y	Y	Y	Y					Y	GR, DR		
047	W007	Y	Y	Y	Y					Y	GR, DR		
047	W008	Y	Y	Y	Y					Y	GR, DR		
047	W009	Y	Y	Y	Y					Y	GR, DR		
047	W010	Y	Y	Y	Y					Y	GR, DR		
047	W011	Y	Y	Y	Y					Y	GR, DR		
047	W012	Y	Y	Y	Y					Y	GR, DR		
047	W013	Y	Y	Y	Y					Y	GR, DR		
047	W015	Y	Y	Y	Y					Y	GR, DR		

METHODS:

- Metal: TAL (Target Analyte List) Metals plus tin: Methods: 6000/7000 Series
- VOA: Volatile Organic Analysis: Method 8240
- SVOA: Semi-volatile Organic Analysis: Method 8270
- Cn: Cyanide (Soil: Method 9010, Water: Method 9012)
- Hexa: Hexavalent Chromium: Method 7195
- Diox: Dioxins
- Oppe: Organophosphate Pesticides: Method 8140
- Herb: Chlorinated Herbicides: Method 8150
- Pest: Chlorinated Pesticides: Method 8080
- Tph: Total Petroleum Hydrocarbons
- Otin: Organotin
- Eng: Engineering Parameters

KEY:

- Y: Analyzed for standard list
- D: Duplicate Analysis
- IR: Method 4181
- DR: Extraction Method 3550, GC Method 8100
- GR: Extraction Method 5030, GC Method 8015

Blank value indicates this method of analysis was not performed

Table 10.2.13
Summary of Chemicals Present in Site Samples, SWMU 47 and AOC 516
Surface Soil
NAVBASE - Charleston, Zone C
Charleston, South Carolina

NAME	CONC UNITS	FREQ	DETECTS Min	DETECTS Max	DETECTS Avg	SCREENING Value	SCREENING # Over	SCREENING Source	NON-DETECTS Min	NON-DETECTS Max	BACKGROUND Value	BACKGROUND # Over
Carcinogenic PAHs												
B(a)P Equiv.	UG/KG	15 - 24	17.772	7648.5	1160.00	88	14		1345.07	1615.48		
Benzo(a)anthracene	UG/KG	15 - 24	74	6100	842.00	880	2	C	690	830		
Benzo(b)fluoranthene	UG/KG	15 - 24	93	10000	1590.00	880	4	C	810	960		
Chrysene	UG/KG	15 - 24	72	8500	1030.00	88000		C	570	680		
Dibenz(a,h)anthracene	UG/KG	4 - 24	65	1000	419.25	88	2	C	430	540		
Indeno(1,2,3-cd)pyrene	UG/KG	10 - 24	110	3200	656.00	880	2	C	480	580		
Benzo(k)fluoranthene	UG/KG	15 - 24	100	11000	1720.00	8800	1	C	650	780		
Benzo(a)pyrene	UG/KG	14 - 24	72	4600	800.00	88	11	C	690	830		
Dioxins												
Dioxin Equiv.	NG/KG	2 - 2	2.5868	3.8856	3.24	1000						
1234678-HpCDD	NG/KG	2 - 2	4.898	21.729	13.31							
1234678-HpCDF	NG/KG	2 - 2	89.4	112.325	100.86							
123478-HxCDD	NG/KG	1 - 2	0.486	0.486	0.49				0.167	0.167		
123678-HxCDD	NG/KG	1 - 2	0.663	0.663	0.66				0.135	0.135		
123789-HxCDD	NG/KG	1 - 2	0.727	0.727	0.73				0.138	0.138		
123478-HxCDF	NG/KG	2 - 2	8.81	11.416	10.11							
123789-HxCDF	NG/KG	1 - 2	0.71	0.71	0.71				0.975	0.975		
123678-HxCDF	NG/KG	2 - 2	2.493	5.784	4.14							
234678-HxCDF	NG/KG	2 - 2	0.711	1.687	1.20							
OCDD	NG/KG	2 - 2	79.68	246.65	163.17							
OCDF	NG/KG	2 - 2	222.084	291.722	256.90							
Petroleum Hydrocarbons												
Petroleum Hydrocarbons, TPH	MG/KG	16 - 16	17.8	2050	326.55	100	10					
Inorganics												
Aluminum (Al)	MG/KG	16 - 16	3045	13900	6413.13	7800	4	N			9990	2
Antimony (Sb)	MG/KG	4 - 16	0.4	1.9	1.02	3.1		N	0.2	0.32	0.55	2
Arsenic (As)	MG/KG	9 - 16	0.38	27.8	6.16	0.43	8	C	0.34	4.1	14.2	1
Barium (Ba)	MG/KG	16 - 16	7.4	170	32.69	550		N			77.2	1

Table 10.2.13
Summary of Chemicals Present in Site Samples, SWMU 47 and AOC 516
Surface Soil
NAVBASE - Charleston, Zone C
Charleston, South Carolina

	CONC		DETECTS			SCREENING			NON-DETECTS		BACKGROUND	
NAME	UNITS	FREQ	Min	Max	Avg	Value	# Over	Source	Min	Max	Value	# Over
Beryllium (Be)	MG/KG	3 - 16	0.37	0.5	0.42	0.15	3	C	0.08	0.49		
Cadmium (Cd)	MG/KG	1 - 16	2.9	2.9	2.90	3.9		N	0.03	0.38	0.65	1
Calcium (Ca)	MG/KG	16 - 16	298	63100	12152.81	NA						
Chromium (Cr)	MG/KG	16 - 16	2.8	44.6	14.30	39	1	N			26.4	3
Chromium (Hexavalent)	MG/KG	1 - 2	0.259	0.259	0.26	39		N	0.01	0.01		
Cobalt (Co)	MG/KG	13 - 16	0.57	9.7	2.97	470		N	0.36	0.6	3.22	4
Copper (Cu)	MG/KG	16 - 16	1.3	416	43.38	310	1	N			34.7	3
Iron (Fe)	MG/KG	16 - 16	924	63900	8115.88	NA		N				
Lead (Pb)	MG/KG	16 - 16	3.3	1120	112.07	400	1	j			330	1
Magnesium (Mg)	MG/KG	16 - 16	134	3650	813.03	NA						
Manganese (Mn)	MG/KG	16 - 16	5.3	331	55.08	180	1	N			92.5	2
Mercury (Hg)	MG/KG	5 - 16	0.13	2.2	0.60	2.3		N	0.09	0.12	0.24	2
Nickel (Ni)	MG/KG	16 - 16	0.73	26.5	6.36	160		N			12.3	2
Potassium (K)	MG/KG	15 - 16	81.3	1010	348.63	NA			67.1	67.1		
Selenium (Se)	MG/KG	9 - 16	0.47	2.4	0.96	39		N	0.46	0.52	1.44	2
Sodium (Na)	MG/KG	5 - 16	295.5	1000	638.70	NA			78.9	183		
Thallium (Tl)	MG/KG	1 - 16	2.1	2.1	2.10	0.63	1		0.47	0.57		
Tin (Sn)	MG/KG	11 - 16	0.94	46.7	9.25	4700			0.62	0.74	2.95	4
Vanadium (V)	MG/KG	16 - 16	1.7	44.1	11.67	55		N			23.4	2
Zinc (Zn)	MG/KG	16 - 16	5.2	1100	140.61	2300		N			159	3
Chlorinated Pesticides												
Aldrin	UG/KG	2 - 16	0.14	0.31	0.23	38		C	1	1.3		
beta-BHC	UG/KG	5 - 16	0.37	64	17.55	350		C	1	1.3		
alpha-BHC	UG/KG	2 - 16	0.13	0.51	0.32	100		C	1	1.3		
delta-BHC	UG/KG	3 - 16	0.46	1.5	1.05	490		I	1	1.3		
gamma-BHC (Lindane)	UG/KG	1 - 16	0.13	0.13	0.13	490		C	1	1.3		
4,4'-DDD	UG/KG	3 - 16	0.4	8.2	5.43	2700		C	3.7	4.4		
4,4'-DDE	UG/KG	5 - 16	4	67	28.00	1900		C	3.7	4.4		
4,4'-DDT	UG/KG	4 - 16	1.6	46	15.58	1900		C	3.7	4.5		
Dieldrin	UG/KG	1 - 16	1.6	1.6	1.60	40		C	1.6	1.9		
Endosulfan I	UG/KG	3 - 16	0.84	4.1	2.18	47000		N	1.6	1.9		

Table 10.2.13
Summary of Chemicals Present in Site Samples, SWMU 47 and AOC 516
Surface Soil
NAVBASE - Charleston, Zone C
Charleston, South Carolina

NAME	CONC UNITS	FREQ			DETECTS Min	Max	Avg	SCREENING Value	# Over	Source	NON-DETECTS Min	Max	BACKGROUND Value	# Over
Endosulfan II	UG/KG	2	-	16	0.28	3.6	1.94	47000		g	1.6	4.4		
Endosulfan sulfate	UG/KG	2	-	16	2.5	7.5	5.00	47000		g	1.9	3.1		
Endrin	UG/KG	1	-	16	0.64	0.64	0.64	2300		N	2.6	3.2		
Endrin aldehyde	UG/KG	4	-	16	0.34	8.8	3.04	2300		h	1	3.7		
Heptachlor	UG/KG	3	-	16	0.27	1.9	1.06	140		C	1	1.3		
Heptachlor epoxide	UG/KG	5	-	16	0.17	5.5	1.73	70		C	1	1.3		
Methoxychlor	UG/KG	5	-	16	0.37	44	20.42	39000		N	3.7	4.6		
Semivolatile Organics														
Acenaphthene	UG/KG	4	-	24	45	340	144.75	470000		N	660	830		
Acenaphthylene	UG/KG	1	-	24	210	210	210.00	470000		e	670	840		
Anthracene	UG/KG	8	-	24	47	1100	256.00	2300000		N	740	930		
Benzo(g,h,i)perylene	UG/KG	10	-	24	100	3000	645.00	310000		f	650	780		
bis(2-Ethylhexyl)phthalate (BEHP)	UG/KG	2	-	24	89	420	254.50	46000		C	790	940		
Dibenz(a,j)acridine	UG/KG	2	-	24	100	190	145.00				410	510		
Dibenzofuran	UG/KG	3	-	24	70	380	183.33	31000		N	690	860		
Di-n-butylphthalate	UG/KG	2	-	24	86	135	110.50	780000		N	770	960		
Diethylphthalate	UG/KG	1	-	24	150	150	150.00	6300000		N	720	900		
Fluoranthene	UG/KG	16	-	24	61	17000	1670.00	310000		N	970	1200		
Fluorene	UG/KG	4	-	24	58	650	243.00	310000		N	690	860		
1-Methylnaphthalene	UG/KG	3	-	24	50	130	81.33	310000		e	1100	1400		
2-Methylnaphthalene	UG/KG	3	-	24	42	100	62.00	310000		e	840	1100		
Naphthalene	UG/KG	2	-	24	150	430	290.00	310000		N	660	830		
Pentachlorophenol	UG/KG	1	-	24	660	660	660.00	5300		C	1400	1800		
Phenanthrene	UG/KG	15	-	24	37	10000	1020.00	310000		f	650	780		
Phenol	UG/KG	1	-	24	68	68	68.00	4700000		N	570	710		
Pyrene	UG/KG	16	-	24	59	12000	1350.00	230000		N	770	910		
Volatile Organics														
Acetone	UG/KG	3	-	16	11	76	44.67	780000		N	40	250		

Notes:

Table 10.2.13
Summary of Chemicals Present in Site Samples, SWMU 47 and AOC 516
Surface Soil
NAVBASE - Charleston, Zone C
Charleston, South Carolina

NAME	CONC UNITS	FREQ	DETECTS Min	DETECTS Max	Avg	SCREENING Value	SCREENING # Over	SCREENING Source	NON-DETECTS Min	NON-DETECTS Max	BACKGROUND Value	BACKGROUND # Over

* Retained as a chemical of potential concern
C The RBC is based on carcinogenic effects
N The RBC is based on noncarcinogenic effects
j Screening level is set equal to the soil action level
l The RBC for gamma-BHC is used as a surrogate
g The RBC for endosulfan is used as a surrogate
h The RBC for endrin is used as a surrogate
e The RBC for acenaphthalene is used as a surrogate
f The RBC for fluoranthene is used as a surrogate

ranging from 17.8 to 2,050 mg/kg. Ten of 16 reported concentrations exceed the soil screening level of 100 mg/kg established for NAVBASE.

Groundwater

As shown in Table 10.2.14, the COPCs identified in shallow groundwater for this site based on first- quarter sampling results were antimony, arsenic, 3,3'-dimethylbenzidine, and lead. Wilcoxon rank sum test analyses did not result in the inclusion of any inorganic parameters that had been screened out on the basis of Reference concentration and RBC comparisons. GRO-TPH and DRO-TPH were each detected in one of the 14 shallow groundwater samples. The DRO fraction concentration was 0.13 mg/L (sample 047GW01001) and the GRO concentration was 0.66 mg/L (sample 047GW01301).

A review of second, third, and fourth-quarter groundwater results was performed to evaluate trends. Neither antimony nor 3,3'-dimethylbenzidine was detected in any monitoring well after the first quarter. Based on this information, it was concluded that initial data did not accurately reflect groundwater quality for these parameters. As a result, neither chemical was carried through the formal assessment.

Arsenic was detected above its RBC and reference concentration in at least one well for each quarter. Lead was reported at an extremely high concentration (467 μg/L) in the first-quarter sample from well 047001, but was nondetect in each subsequent round. the initial result was thus considered anomalous, and was not considered in exposure estimates. Lead was not retained as a COPC for groundwater pathways based on this finding and the fact that the four-quarter mean in no onsite monitoring well exceeded the screening concentration (15 μg/L TTAL).

Thallium was not detected in first-quarter groundwater samples. It was detected inconsistently in subsequent rounds in several wells. In no instance was it detected in multiple rounds in the same

Table 10.2.14
Summary of Chemicals Present in Site Samples, SWMU 47 and AOC 516
Shallow Groundwater, First Quarter
NAVBASE - Charleston, Zone C
Charleston, South Carolina

NAME	CONC UNITS	FREQ	DETECTS Min	DETECTS Max	DETECTS Avg	SCREENING Value	SCREENING # Over	SCREENING Source	NON-DETECTS Min	NON-DETECTS Max	BACKGROUND Value	BACKGROUND # Over
Dioxins												
Dioxin Equiv.	PG/L	1 - 1	0.301	0.301	0.30	0.43						
123789-HxCDF	PG/L	1 - 1	2.815	2.815	2.82							
OCDD	PG/L	1 - 1	17.677	17.677	17.68							
OCDF	PG/L	1 - 1	1.853	1.853	1.85							
Petroleum Hydrocarbons												
TPH - Diesel Range Organics	MG/L	1 - 14	0.13	0.13	0.13	0.1	1		0.5	0.5		
TPH - Gasoline Range Organics	MG/L	1 - 14	0.66	0.66	0.66	0.1	1		0.5	0.5		
Inorganics												
Aluminum (Al)	UG/L	7 - 14	275	1330	548.29	3700		N	61.8	201	410	4
Antimony (Sb)	UG/L	2 - 14	3.1	53.1	28.10	1.5	2	N	1.9	1.9		
Arsenic (As)	UG/L	5 - 14	3.9	46.3	14.52	0.045	5	C	3.2	3.2	6.07	4
Barium (Ba)	UG/L	6 - 14	13.4	93.4	43.88	260		N	6.5	40.2	16.7	5
Calcium (Ca)	UG/L	14 - 14	7390	156000	45092.14	NA	14					
Chromium (Cr)	UG/L	8 - 14	0.93	3.5	1.75	18		N	0.9	0.9	1.99	2
Cobalt (Co)	UG/L	1 - 14	1.3	1.3	1.30	220		N	0.6	0.6	1.33	
Copper (Cu)	UG/L	4 - 14	2.1	4.2	3.05	150		N	0.7	5	1.9	4
Iron (Fe)	UG/L	14 - 14	182	25700	5636.43	1100	8	N				
Lead (Pb)	UG/L	5 - 14	4.6	467	98.02	15	1	j	3.1	10.4	3.27	5
Magnesium (Mg)	UG/L	14 - 14	1440	24100	7512.14	NA	14					
Manganese (Mn)	UG/L	14 - 14	23.7	598	136.14	84	7	N			608	
Nickel (Ni)	UG/L	3 - 14	2.3	4.4	3.27	73		N	1.4	1.4	3.59	1
Potassium (K)	UG/L	14 - 14	1230	12700	4515.00	NA	14					
Selenium (Se)	UG/L	1 - 14	4.5	4.5	4.50	18		N	4.4	4.4		
Silver (Ag)	UG/L	1 - 14	0.62	0.62	0.62	18		N	0.5	0.5	1.26	
Sodium (Na)	UG/L	14 - 14	5290	42700	22192.86	NA	14					
Tin (Sn)	UG/L	2 - 14	9.7	77.6	43.65	2200			5.9	56.3		
Vanadium (V)	UG/L	11 - 14	0.48	7.3	2.23	26		N	0.97	1.3	1.96	3
Zinc (Zn)	UG/L	9 - 14	14.8	106	54.79	1100		N	2.1	7.5	13.2	9

Table 10.2.14
Summary of Chemicals Present in Site Samples, SWMU 47 and AOC 516
Shallow Groundwater, First Quarter
NAVBASE - Charleston, Zone C
Charleston, South Carolina

NAME	CONC UNITS	FREQ	DETECTS Min	DETECTS Max	Avg	SCREENING Value	SCREENING # Over	Source	NON-DETECTS Min	NON-DETECTS Max	BACKGROUND Value	BACKGROUND # Over
Chlorinated Pesticides												
Heptachlor epoxide	UG/L	1 - 14	0.035	0.035	0.035	0.0012	1	C	0.03	0.03		
Semivolatile Organics												
Acenaphthene	UG/L	2 - 14	1	1	1.00	220		N	10	10		
Butylbenzylphthalate	UG/L	3 - 14	4	4	4.00	730		N	10	10		
Diethylphthalate	UG/L	1 - 14	1	1	1.00	2900		N	15	15		
3,3-Dimethylbenzidine	UG/L	1 - 14	100	100	100.00	0.0073	1	C	100	100		
Fluoranthene	UG/L	1 - 14	3	3	3.00	150		N	20	20		
Phenanthrene	UG/L	1 - 14	1	1	1.00	150		k	15	15		
Pyrene	UG/L	1 - 14	3	3	3.00	110		N	10	10		
Volatile Organics												
Carbon disulfide	UG/L	2 - 14	2	7	4.50	100		N	10	10		

Notes:
- * Retained as a chemical of potential concern
- C The RBC is based on carcinogenic effects
- N The RBC is based on noncarcinogenic effects
- j Screening level is set equal to the treatment technique action level
- k RBC for naphthalene used as a surrogate

well. Due to its erratic appearance, thallium was not formally assessed as a groundwater COPC. The effects of its omission are discussed in the risk uncertainty section,

Tetrachloroethene was detected in the second-quarter sample from well 047013 above its RBC (7μg/L). No other detection was reported in any well over the four quarterly rounds. As a result, this detection was not considered to be representative of true groundwater quality.

Aluminum was detected in one second-quarter sample from well 047005 in excess of the tap water RBC. Subsequent sampling rounds did not confirm this exceedance. As a result, aluminum was not retained as a groundwater COPC.

Based on the preceding analyses, arsenic was retained as the sole groundwater COPC.

10.2.6.3 Exposure Assessment

Exposure Setting

Most of SWMU 47 is covered by Buildings NSC-64, NSC-66, and NSC-67 and associated parking areas. Soil is exposed exclusively in small areas immediately surrounding the building and in median strips throughout the parking area. The site is within a heavily developed area of NAVBASE and most surrounding parcels are also occupied by buildings and/or parking lots. The SWMU 47 area is scheduled for redevelopment as a parking lot, according to base reuse plans. Areas to the south and southeast of the site have been proposed as residential and community support areas. Property north and east of SWMU 47 has been proposed as office and training areas that will likely maintain current features and/or entail additional construction.

Potentially Exposed Populations

Potentially exposed populations are current and future site workers. Additional potentially exposed populations are hypothetical future site residents. Future site resident and worker exposure scenarios were addressed in this risk assessment. The hypothetical future site worker scenario assumed continuous exposure to surface soil conditions and the use of shallow groundwater as a potable water source. Current site workers' exposure would be less than that assumed for the hypothetical future site worker scenario because of their limited soil contact and because groundwater is not currently used onsite as potable or process water. Therefore, future worker assessment is considered protective of current site users. The future site resident scenario was built on the premise that existing buildings would be removed and replaced with dwellings. In addition, the future site residents were assumed to use the shallow aquifer onsite as a source of drinking water.

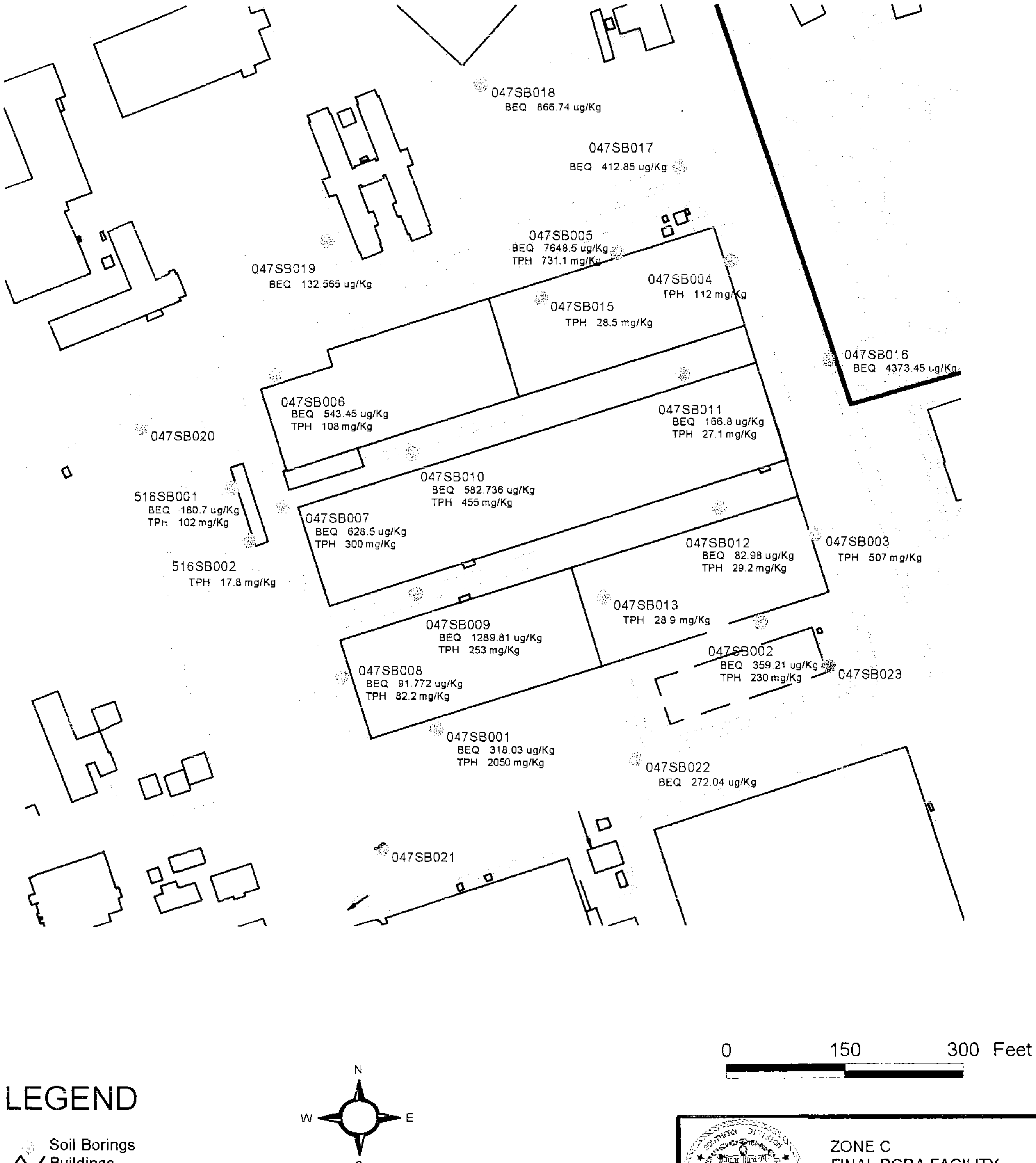
Exposure Pathways

Exposure pathways for the site workers are dermal contact and incidental ingestion of surface soils, and ingestion of shallow groundwater through potable use. VOCs were not detected in the shallow aquifer, and thus inhalation of volatilized groundwater contaminants was not considered a viable exposure pathway. The exposure pathways for future residential land use are the same as those for the future site worker. In addition, the hypothetical future site worker scenario assumed continuous exposure to surface soil and groundwater conditions. Uniform exposure was assumed for all sample locations. Table 10.2.15 justifies the exposure pathways assessed in this HHRA.

Exposure Point Concentrations

As discussed in Section 7, UCLs are generally calculated for datasets consisting of at least 10 samples. Table 10.2.16 shows the UCLs calculated for each identified soil COPC.

Figure 10.2.3 shows the distribution of BEQ and TPH concentrations over SWMU 47. As shown, BEQs were detected above the residential RBC throughout SWMU 47. The UCL concentrations computed for aluminum and arsenic are less than the Zone C background reference concentrations



LEGEND

Soil Borings
Buildings
Zone C Boundary
Water
Sidewalk
Railroad
Road
Property Line
Fence
Transformer
Golf Course

NOTE:
BEQ Benzo(a)pyrene Equivalents
TPH Total Petroleum Hydrocarbons

ZONE C
FINAL RCRA FACILITY
INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 10.2.3
SWMU 47/AOC 516
SURFACE SOIL
BEQ & TPH CONCENTRATIONS

DWG DATE: 10/10/97 | DWG NAME: CHARLC.APR

Table 10.2.15
Exposure Pathways Summary — SWMU 47 (AOC 516 and SWMU 47)
NAVBASE — Zone C
Charleston, South Carolina

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Current Land Uses			
Current Site Users/Maintenance	Air, Inhalation of gaseous contaminants emanating from soil	No	Based on the COPCs identified in this HHRA for SWMU 47, no significant VOC concentrations were identified at this site.
	Air, Inhalation of chemicals entrained in fugitive dust	No	Exposure to dust generated by site users traversing the area would be minimized by paved, submerged, and/or vegetated soils.
	Shallow groundwater, Ingestion of contaminants during potable or general use	No (Qualified)	Shallow groundwater is not currently used as a source of potable or non-residential water at SWMU 47. Future land use assessment is considered to be protective of current receptors.
	Shallow groundwater, Inhalation of volatilized shallow groundwater contaminants	No	VOCs were not detected in shallow groundwater.
	Soil, Incidental ingestion	No (Qualified)	Future land use assessment is considered to be protective of current receptors.
	Soil, Dermal contact	No (Qualified)	Future land use assessment is considered to be protective of current receptors.
Future Land Uses			
Future Site Residents (Child and Adult) and Future Site Worker	Air, Inhalation of gaseous contaminants emanating from soil	No	Based on the COPCs identified in this HHRA for SWMU 47, no significant VOC concentrations were identified at this site.
	Air, Inhalation of chemicals entrained in fugitive dust	No	Exposure to dust generated by site users traversing the area would be minimized by paved and/or vegetated soils.
	Shallow groundwater, Ingestion of contaminants during potable or general use	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Shallow groundwater, Inhalation of volatilized contaminants during domestic use	No	VOCs were not detected in shallow groundwater.
	Soil, Incidental ingestion	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Soil, Dermal contact	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.

Table 10.2.15
Exposure Pathways Summary — SWMU 47 (AOC 516 and SWMU 47)
NAVBASE — Zone C
Charleston, South Carolina

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
	Wild game or domestic animals, Ingestion of tissue impacted by media contamination	No	Hunting/taking of game and/or raising livestock is prohibited within the Charleston, South Carolina, city limits.
	Fruits and vegetables, Ingestion of plant tissues grown in media	No	The potential for significant exposure via this pathway is low relative to that of other exposure pathways assessed.

for these elements. The computed surface soil beryllium UCL concentration (0.267 mg/kg) is comparable to the detections reported in Zone C background samples, although no background reference concentration was calculated for this element.

A review of soil data showed that the maximum concentrations of arsenic, copper, lead, manganese, and thallium were reported at location 047007. As such, this boring, as well as borings 047008, 047009, and 516001, represent a potential hot spot. The suspected source of metals was located in this area. Arsenic and thallium exceeded their RBCs and reference concentrations exclusively at 047007. Based on the limited extent of apparent impacts, a hot-spot analysis was used, applying an FI/FC of 0.55, indicating the affected area represents approximately one-half of a standard 0.5 acre exposure area.

For copper, the area impacted was estimated to be approximately 0.5 acres, thus the mean concentration at affected locations (borings 047007, 047008, and 047009) was used as the EPC. Manganese was detected above its RBC at two locations (047007 and 5516001). The maximum manganese concentration was applied as the EPC with an FI/FC of 0.5 to reflect the limited extent. The process used to estimate lead exposure is discussed later.

Table 10.2.16
Statistical Analysis of COPCs
Surface Soils at SWMU 47 and AOC 516
Naval Base Charleston Zone H
Charleston, South Carolina

COPC	n	Natural Log Transforme mean	SD	H-stat	UCL (mg/kg)	MAX (mg/kg)	EPC (mg/kg)		TEF	Adjusted EPC (mg/kg)
Benzo(a)pyrene Equivalents	24	5.54646	1.30841	2.954	1.351	7.649	1.351	UCL Used	1	1.351
Aluminum	16	8.66719	0.45313	2.009	8143.1	13900	8143	UCL Used	NA	8143
Arsenic	16	-0.04714	1.70917	3.946	23.4	27.8	27.8	MAX Used Hot Spot	NA	27.8
Beryllium	16	-1.53695	0.32914	1.898	0.267	0.5	0.3	UCL Used	NA	0.27
Copper	16	2.00911	1.76846	4.056	226.939	416	208	Hot Spot	NA	208
Lead	16	2.98762	1.77198	4.062	611.647	1120	385	Hot Spot	NA	385
Manganese	16	ND	ND	ND	ND	331	331	MAX Used Hot Spot	NA	331
Thallium	16	0.09211	0.17329	1.787	1.2057	2.1	2.1	MAX Used Hot Spot	NA	2.1

NOTES:

mean arithmetic mean of the logtransformed data
n number of samples analyzed
SD standard deviation for a sample of data
H-stat "H" statistic from Gilbert 1987; cuboidal interpolation was used to determine the value in accordance with USEPA Supplemental Guidance to RAGS, Calculating the Concentration Term
NA not applicable
TEF toxic equivalency factor
EPC exposure point concentration
UCL 95 percentile upper confidence level mean
MAX maximum reported concentration
HOT SPOT the mean and/or maximum concentration was used to estimate exposure for impacts limited to a small area of the site.

Fourteen shallow monitoring wells were installed onsite. Arsenic was the only COPC identified. Although several wells produced results above the RBC, only well 047011 consistently had arsenic levels above background. As a result, the first-quarter result from this well was compared to the RBC and retained for further analysis.

Quantification of Exposure

Soil

CDIs for ingestion and dermal contact with soil are shown in Tables 10.2.17 and 10.2.18, respectively.

Groundwater

The CDIs for groundwater ingestion are presented in Table 10.2.19. No VOCs were detected in shallow groundwater, and thus inhalation pathway exposures were not considered.

10.2.6.4 Toxicity Assessment

Toxicity assessment terms and methods are discussed in Section 7. Table 10.2.20 presents toxicological information specific to each COPC identified at SWMU 47. This information was used to quantify risk/hazard associated with soil and groundwater contaminants. Each COC is profiled below.

Aluminum is one of the most abundant metals in the earth's crust (7% aluminum), and it is ubiquitous in air and water, as well as soil. This metal is water-soluble, silvery, and ductile, which suggests its usefulness in many processes. Ingesting aluminum can affect the absorption of other elements within the gastrointestinal tract and can alter intestinal function. Aluminum can potentially interfere with the absorption of essential nutrients and cholesterol. Another effect on the gastrointestinal system is the inhibition of acetylcholine-induced contractions, which are part of the neuro-muscular system controlling bowel muscles. The effect could explain why aluminum-

Table 10.2.17
Chronic Daily Intakes (CDI)
Incidental Ingestion of Surface Soil (0-1')
SWMU 47 and AOC 516 Zone C
Naval Base Charleston
Charleston, SC

Chemical	TEF	Fraction Ingested fro Contaminate Source	Exposure Point Concentration (mg/kg)	Potential Future Resident adult H-CDI (mg/kg-day)	Potential Future Resident child H-CDI (mg/kg-day)	Potential Futur Resident lwa C-CDI (mg/kg-day)	Potential Curren Worker adult H-CDI (mg/kg-day)	Potential Current Worker adult C-CDI (mg/kg-day)
Benzo(a)pyrene Equival	1	1	1.351	1.85E-06	1.73E-05	2.12E-06	6.61E-07	2.36E-07
Aluminum	NA	1	8143	1.12E-02	1.04E-01	1.27E-02	3.98E-03	1.42E-03
Arsenic	NA	0.5	27.8	1.90E-05	1.78E-04	2.18E-05	6.80E-06	2.43E-06
Beryllium	NA	1	0.3	3.66E-07	3.41E-06	4.18E-07	1.31E-07	4.67E-08
Copper	NA	1	208	2.85E-04	2.66E-03	3.26E-04	1.02E-04	3.63E-05
Lead	NA	1	385	5.27E-04	4.92E-03	6.03E-04	1.88E-04	6.73E-05
Manganese	NA	0.5	331	2.27E-04	2.12E-03	2.59E-04	8.10E-05	2.89E-05
Thallium	NA	0.5	2.1	1.44E-06	1.34E-05	1.64E-06	5.14E-07	1.83E-07

NOTES:

TEF	toxic equivalency factor relative to Benzo(a)pyrene
lwa	lifetime weighted average; used to calculate carcinogenic CDI, RAGS Parts A and B
CDI	Chronic Daily Intake in mg/kg-day
H-CDI	CDI for hazard quotient
C-CDI	CDI for excess cancer risk
*	Reflects the estimated fraction of the site impacted by the corresponding COPC.

Table 10.2.18
Chronic Daily Intakes (CDI)
Dermal Contact with Surface Soil (0-1')
SWMU 47 and AOC 516 Zone C
Naval Base Charleston
Charleston, SC

Chemical	TEF	Adjusted Exposure Point Concentratio (mg/kg)	Fraction Contacted fr Contaminate Source *	Dermal Absorption Factor (unitless)	Potential Future Resident adult H-CDI (mg/kg-day)	Potential Future Resident child H-CDI (mg/kg-day)	Potential Futur Resident lwa C-CDI (mg/kg-day)	Potential Curren Worker adult H-CDI (mg/kg-day)	Potential Current Worker adult C-CDI (mg/kg-day)
Benzo(a)pyrene Equiv	1	1.351	1	0.01	7.59E-07	2.50E-06	4.75E-07	5.42E-07	1.94E-07
Aluminum	NA	8143.1	1	0.001	4.57E-04	1.51E-03	2.86E-04	3.27E-04	1.17E-04
Arsenic	NA	27.8	0.5	0.001	7.81E-07	2.58E-06	4.89E-07	5.58E-07	1.99E-07
Beryllium	NA	0.267	1	0.001	1.50E-08	4.95E-08	9.39E-09	1.07E-08	3.83E-09
Copper	NA	208.0	1	0.001	1.17E-05	3.86E-05	7.31E-06	8.34E-06	2.98E-06
Lead	NA	385.0	1	0.001	2.16E-05	7.14E-05	1.35E-05	1.54E-05	5.52E-06
Manganese	NA	331	0.5	0.001	9.30E-06	3.07E-05	5.82E-06	6.64E-06	2.37E-06
Thallium	NA	2.10	0.5	0.001	5.90E-08	1.95E-07	3.69E-08	4.21E-08	1.50E-08

NOTES:

TEF Toxic Equivalency Factor relative to Benzo(a)pyrene
CDI Chronic Daily Intake in mg/kg-day
H-CDI CDI for hazard quotient
C-CDI CDI for excess cancer risk
- The dermal absorption factor was applied to the exposure point concentration to reflect the different trans-dermal migration of inorganic versus organic chemicals
* Reflects the estimated fraction of the site impacted by the corresponding COPC.

Table 10.2.19
Chronic Daily Intakes (CDI)
Ingestion of COPCs in Shallow Groundwater
SWMU 47 and AOC 516 Zone C
Naval Base Charleston
Charleston, SC

Chemical	Adjusted Exposure Point Concentration (mg/liter)	Potential Future Resident adult H-CDI (mg/kg-day)	Potential Future Resident child H-CDI (mg/kg-day)	Potential Futur Resident lwa C-CDI (mg/kg-day)	Potential Future Worker adult H-CDI (mg/kg-day)	Potential Future Worker adult C-CDI (mg/kg-day)
Arsenic	0.046	1.27E-03	2.96E-03	6.98E-04	4.53E-04	2.23E-04

NOTES:

lwa lifetime weighted average
CDI Chronic Daily Intake
H-CDI Non-carcinogenic hazard based Chronic Daily Intake
C-CDI Carcinogenic risk based Chronic Daily Intake

Table 10.2.20
Toxicological Database Information
for Chemicals of Potential Concern
SWMU 47
NAVBASE Charleston, Zone C

Non-Carcinogenic Toxicity Data

Chemical	Oral Reference Dose (mg/kg/day)		Confidence Level	Critical Effect	Uncertainty Factor Oral	Inhalation Reference Dose (mg/kg/day)		Confidence Level	Critical Effect	Uncertainty Factor Inhalation
Aluminum	1	e			ND	ND				ND
Arsenic	0.0003	a	M	hyperpigmentation	3	ND				ND
Benzo(a)pyrene Equivalents	ND				ND	ND				ND
Beryllium	0.005	a	L	microscopic organ changes	100	ND				ND
Copper	0.0371	b	NA	NA	ND	ND				ND
Lead	ND				ND	ND				ND
Manganese (food)	0.047	a	NA	neurological effects	1	ND				ND
Manganese (water)	0.023	a	NA	neurological effects	1	1.43E-05	a	M	neurological effects	1000
Thallium	8E-05	a		increased SGOT (liver) increased serum LDH	3000	ND				ND

NOTES:

a Integrated Risk Information System (IRIS)
b Health Effects Assessment Summary Tables (HEAST)
c HEAST alternative method
d USEPA Region III Screening Tables
e EPA Environmental Criteria and Assessment Office - Cincinnati (provisional)
f Withdrawn from IRIS or HEAST
NA Not applicable or not available
ND Not determined due to lack of information

Table 10.2.20
Toxicological Database Information
for Chemicals of Potential Concern
SWMU 47
NAVBASE Charleston, Zone C

Carcinogenic Toxicity Data

Chemical	Oral Slope Factor [(mg/kg/day)]-1		Inhalation Slope Factor [(mg/kg/day)]-1		Weight of Evidence	Tumor Type
Aluminum	ND		ND		ND	
Arsenic	1.5	a	15.1	a	A	various
Benzo(a)pyrene Equivalents	7.3	a			B2	mutagen
Beryllium	4.3	a	8.4	a	B2	osteosarcoma
Copper	ND		ND		D	
Lead	ND		ND		B2	various
Manganese (food)	ND		ND		D	
Manganese (water)	ND		ND		D	
Thallium	ND		ND		D	

containing antacids often produce constipation. Aluminum dust is moderately flammable and explosive in heat. Inhaling this dust can cause fibrosis (aluminosis) (Klaassen, et al., 1986) (Dreisbach, et al., 1987). No data are available on an applicable SF or the USEPA cancer group. The USEPA Region IV Office of Health Assessment suggested using the provisional oral RfD of 1.0 mg/kg-day. The aesthetic-based SMCL for drinking water is 50 to 200 μg/L (USEPA, Office of Water, 1994).

Arsenic exposure via the ingestion route causes darkening and hardening of the skin in chronically exposed humans. Inhalation exposure to arsenic causes neurological deficits, anemia, and cardiovascular effects (Klaassen, et al., 1986). USEPA set 0.3 μg/kg/day as the RfD for arsenic based on a NOAEL of 0.8 μg/kg-day in a human exposure study. Arsenic's effects on the nervous and cardiovascular systems are primarily associated with acute exposure to higher levels. Exposure to arsenic-containing materials has been shown to cause cancer in humans. Inhalation of these materials can lead to increased lung cancer risk, and ingestion of these materials is associated with increased skin cancer rates. Arsenic has been classified as a group A carcinogen by USEPA, which set the 1.5 $(mg/kg\text{-}day)^{-1}$ SF for arsenic. As listed in IRIS (search date September 1, 1995), the basis for the classification is sufficient evidence from human data. An increased lung cancer mortality was observed in multiple human populations exposed primarily through inhalation. Also, increased mortality from multiple internal organ cancers (liver, kidney, lung, and bladder) and an increased incidence of skin cancer were observed in populations consuming drinking water high in inorganic arsenic. Human milk contains about 3 μg/L arsenic (Klaassen, et al., 1986). The RBC for arsenic in tap water is 0.038 μg/L. As listed in IRIS (search date September 1, 1995), the critical effect of this chemical is hyperpigmentation, keratosis, and possible vascular complications. The uncertainty factor was determined to be 3 and the modifying factor was determined to be 1.

Manganese is an essential nutrient, but chronic exposure (0.8 mg/kg-day) causes mental disturbances. Studies have shown that manganese uptake from water is greater than manganese uptake from food, and the elderly appear to be more sensitive than children (Klaassen, et al., 1986) (Dreisbach, et al., 1987). Because of the different uptake rates in water and food, USEPA set two oral RfDs – one for water and one for food. These RfDs are 0.005 and 0.14 mg/kg-day. Inhalation of manganese dust causes neurological effects and increased incidence of pneumonia. An inhalation RfD was set to 0.0000143 mg/kg-day. According to USEPA, manganese can not be classified as to its carcinogenicity. Therefore, the cancer class for manganese is group D. As listed in IRIS (search date June 29, 1995), the basis for the classification is existing studies that are inadequate to assess the carcinogenicity of manganese. Manganese is an element considered essential to human health. The typical vitamin supplement dose of manganese is 2.5 mg/day. As listed in IRIS (search date June 29, 1995), the critical effects of this chemical in water in the oral summary are CNS effects. The uncertainty factor was determined to be 1 and the modifying factor was determined to be 1. The critical effects of this chemical in food in the oral summary are CNS effects. The uncertainty factor was 1 and the modifying factor was 1. As listed in IRIS (search date June 29, 1995), the critical affect of this chemical in the inhalation summary is impairment of neuro-behavioral function. The uncertainty factor was 1000 and the modifying factor was 1. The IRIS RfC is 0.00005 mg/m^3.

Polyaromatic hydrocarbons or BaP equivalents include the following list of COPCs:

Benzo(a)anthracene	TEF	0.1
Benzo(b)fluoranthene	TEF	0.1
Dibenz(a,h)anthracene	TEF	1.0
Benzo(k)fluoranthene	TEF	0.01
Benzo(a)pyrene	TEF	1.0
Indeno(1,2,3-cd)pyrene	TEF	0.1
Chrysene	TEF	0.001

Some PAHs are toxic to the liver, kidney, and blood. However, the toxic effects of the PAHs above have not been well established. There are no RfDs for the PAHs above due to a lack of data. All PAHs listed above are classified by USEPA as B2 carcinogens, and their carcinogenicity is addressed relative to that of BaP, having an oral SF 7.3 $(mg/kg\text{-}day)^{-1}$. Toxicity Equivalency Factors, also set by USEPA, are multipliers applied to the detected concentrations, which are subsequently used to calculate excess cancer risk. These multipliers are discussed further in the exposure and toxicity assessment sections. Most carcinogenic PAHs have been classified as such due to animal studies using large doses of purified PAHs. There is some doubt as to the validity of these listings, and the SFs listed in USEPA's RBC table are provisional. However, these PAHs are carcinogens when the exposure involves a mixture of other carcinogenic substances (e.g., coal tar, soot, cigarette smoke, etc.). As listed in IRIS (search data June 28, 1995), the basis for the BaP B2 classification is human data specifically linking BaP to a carcinogenic effect are lacking. There are, however, multiple animal studies in many species demonstrating BaP to be carcinogenic by numerous routes.

BaP has produced positive results in numerous genotoxicity assays. At the June 1992 CRAVE Work Group meeting, a revised risk estimate for benzo (a)pyrene was verified (see Additional Comments for Oral Exposure). This section provides information on three aspects of the carcinogenic risk assessment for the agent in question: the USEPA classification and quantitative estimates of exposure. The classification reflects a weight-of-evidence judgment of the likelihood that the agent is a human carcinogen. The quantitative risk estimates are presented in application of a low-dose extrapolation procedure and presented as the risk per mg/kg-day. The unit risk is the quantitative estimate in terms of either risk per $\mu g/L$ drinking water or risk per $\mu g/m^3$ air breathed. The third form in which risk is presented is drinking water or air concentration providing cancer risks of 1 in 10,000 or 1 in 1,000,000. The Carcinogenicity Background Document provides details on the carcinogenicity values found in IRIS. Users are referred to the

Oral Reference Dose and Reference Concentration sections for information on long-term toxic effects other than carcinogenicity.

As listed in IRIS (search date June 28, 1995), the basis for the dibenz(a,h)anthracene and benzo(b)fluoranthene B2 classification is no human data and sufficient data from animal bioassays. Benzo(b)fluoranthene produced tumors in mice after lung implantation, intraperitoneal or subcutaneous injection, and skin painting. As listed in IRIS (search date June 28, 1995), the basis for the benzo(a)anthracene B2 classification is no human data and sufficient data from animal bioassays. Benzo(a)anthracene produced tumors in mice exposed by gavage; intraperitoneal, subcutaneous or intramuscular injection; and topical application. Benzo(a)anthracene produced mutations in bacteria and in mammalian cells, and transformed mammalian cells in culture. As listed in IRIS (search date June 28, 1995) the basis for the benzo(k)fluoranthene B2 classification is no human data and sufficient data from animal bioassays. Benzo(k)fluoranthene produced tumors after lung implantation in mice and when administered with a promoting agent in skin-painting studies. Equivocal results have been found in a lung adenoma assay in mice. Benzo(k)fluoranthene is mutagenic in bacteria. (Klaassen, et al., 1986).

Other PAHs — those not classified by USEPA as carcinogens — are toxic to the liver, kidney and blood. This group of PAHs includes compounds such as pyrene, acenaphthene, acenaphthylene, benzo(g,h,i)perylene, and phenanthrene. USEPA determined RfDs for only two of these compounds: pyrene's RfDo of 0.03 mg/kg-day is also used as a surrogate RfDo for phenanthrene. The RfDo for acenaphthene was 0.06 mg/kg-day.

Lead has been classified as a group B2 carcinogen by USEPA based on animal data. No RfD or SF has been set by USEPA. However, an action level for soil protective of child residents has been proposed by USEPA Region IV, 400 mg/kg. USEPA's OSWER has recommended a 1,000 mg/kg cleanup standard for industrial properties. USEPA's Office of Water has established a treatment technique action level of 15 μg/L. As listed in IRIS (search date September 17, 1995), the basis for classification is sufficient animal evidence. Ten rat bioassays and one mouse assay have shown statistically significant increases in renal tumors with dietary and subcutaneous exposure to several soluble lead salts. Animal assays provide reproducible results in several laboratories, in multiple rat strains with some evidence of multiple tumor sites. Short-term studies show that lead affects gene expression. Human evidence is inadequate. An RfD and SF have not been set because of the confounding nature of lead toxicity. Lead can accumulate in bone marrow, and effects have been observed in the CNS, blood, and mental development of children. RfDs are based on the assumption that a threshold must be exceeded to result in toxic effects (other than carcinogenicity). Once lead accumulates in the body, other influences cause the actual levels in the blood to fluctuate – sometimes the lead is attached to binding sites; sometimes lead is free flowing. If an exposed individual has previously been exposed to lead, this individual could lose weight and set fat-bound lead free. This fluctuation and lack of previous lead exposure data are two of the reasons lead effects are difficult to predict (Klaassen, et al., 1986).

Beryllium exposure via the inhalation route can cause inflammation of the lungs, a condition known as acute beryllium disease, as a result of short-term exposure to high concentrations. Removal from exposure results in a reversal of the symptoms. Chronic exposure to much lower levels of beryllium or beryllium oxide by inhalation has been reported to cause chronic beryllium disease, with symptoms including shortness of breath, scarring of the lungs, and berylliosis, which is noncancerous growths in the lungs of humans. Both forms of beryllium disease can be fatal, depending on the severity of the exposure. Additionally, a skin allergy may develop when soluble beryllium compounds contact the skin of sensitized individuals (Gradient, 1991). An oral RfD of 0.0054 mg/kg-day has been set for beryllium based on a chronic oral bioassay (rats were the study species) which determined no adverse effect occurs at 0.54 mg/kg-day. Beryllium has been classified by USEPA as a group B2 carcinogen based on animal studies. It has been shown to induce lung cancer via inhalation in rats and monkeys, and to induce osteosarcomas in rabbits via intravenous or intramedullary injection. Human epidemiology studies of beryllium are considered to be inadequate. As listed in IRIS (search date June 28, 1995), the basis for the classification is that beryllium has been shown to induce lung cancer via inhalation in rats and monkeys and to induce osteosarcomas in rabbits via intravenous or intramedullary injection. Human epidemiology studies are considered inadequate. An inhalation slope factor of 8.4 $(mg/kg\text{-}day)^{-1}$ and an oral SF of 4.3 $(mg/kg\text{-}day)^{-1}$ have been set by USEPA. As listed in IRIS (search date June 28, 1995), the critical effect of this chemical is no adverse effect. The uncertainty factor was 100 and the modifying factor was 1. The IRIS RfD in drinking water is 0.005 mg/kg-day.

Copper is a nutritionally essential element, necessary for many of the body's enzymes. In the past, lead pipes and solder were used for residential water pipes, and resulting lead concentrations in drinking water exceeded the guidelines set by the EPA. Copper has been used to replace water pipes in residences due to its lower toxicity to man. Short-term exposure to copper can result in anemia (the lack of iron), the breakdown of red blood cells, and liver and kidney lesions. The target organs for copper are the liver, kidney, and red blood cell. Vitamin C reduces copper uptake from the gut, and other substances can also influence copper uptake. Copper fumes can cause metal fume fever (Klaassen, et al., 1986). As listed in IRIS (search date June 28, 1995), the basis for the D classification is no human data, inadequate animal data from assays of copper compounds, and equivocal mutagenicity data. The RfD set by the EPA is 0.0371 mg/kg-day, which is 2.6 mg/day for the average adult (70 kg). In typical vitamin supplements, 2 mg/day is the approximate dose (NRC, 1989).

Thallium is readily absorbed through the gut and skin. Primary effects are stomach and bowel disturbances, kidney and liver damage, and neurological disturbances. Thallium was used in the past as a rodenticide and ant killer, and its use for these purposes is now prohibited. This element remains in the body for a relatively long time, and could accumulate if the chronic dose is large (Klaassen, et al., 1986) (Dreisbach, et al., 1987). USEPA's RfDo for thallium is 0.00008 mg/kg-day.

10.2.6.5 Risk Characterization

Surface Soil Pathways

Exposure to surface soil onsite was evaluated under both residential and industrial (site worker) scenarios. The incidental ingestion and dermal contact exposure pathways were evaluated. For noncarcinogenic contaminants evaluated for future site residents, hazard was computed separately to address child and adult exposure. Tables 10.2.21 and 10.2.22 present the computed carcinogenic risks and/or HQs associated with the incidental ingestion of and dermal contact with site surface soil, respectively.

Hypothetical Site Residents

The ingestion ILCR (based on the adult and child lifetime weighted average) for SWMU 47 surface soil is 5E-5. The dermal pathway ILCR is 1E-5. BEQs and arsenic were the primary contributors for each pathway.

The computed HQs for the adult resident were less than 0.1 for the soil ingestion and dermal contact pathways. The computed HQs for the child ingestion and dermal contact pathways were 1 and 0.1, respectively. Arsenic was the primary contributor for both pathways, with aluminum and thallium as the only other significant contributors.

Hypothetical Site Workers

Site worker ILCRs are 6E-6 and 4E-6 for the ingestion and dermal contact pathways, respectively. BEQs and arsenic were the primary contributors for both pathways. The HQs for the ingestion and dermal pathways were both projected to be less than 0.04 for the hypothetical site worker scenario.

The SWMU 47 area is almost entirely covered by building and/or asphalt parking lots. Small grassy areas are maintained around each building and in median strips throughout the parking

Table 10.2.21
Hazard Quotients and Incremental Lifetime Cancer Risks
Incidental Surface Soil Ingestion
SWMU 47 and AOC 516 Zone C
Naval Base Charleston
Charleston, SC

Chemical	Oral RfD Used (mg/kg-day)	Oral SF Used (mg/kg-day)-1	Potential Future Resident adult Hazard Quotient	Potential Future Resident child Hazard Quotient	Potential Futur Resident lwa ILCR	Potential Curren Worker adult Hazard Quotient	Potential Current Worker adult ILCR
Benzo(a)pyrene Equivale	NA	7.3	ND	ND	1.5E-05	ND	1.7E-06
Aluminum	1	NA	0.011	0.10	ND	0.004	ND
Arsenic	0.0003	1.5	0.1	0.6	3.3E-05	0.02	3.6E-06
Beryllium	0.005	4.3	0.0001	0.001	1.8E-06	0.00003	2.0E-07
Copper	0.04	NA	0.007	0.07	ND	0.003	ND
Lead	NA	NA	ND	ND	ND	ND	ND
Manganese	0.047	NA	0.005	0.05	ND	0.002	ND
Thallium	8E-05	NA	0.02	0.2	ND	0.006	ND
SUM Hazard Index/ILCR			0.1	1.0	5E-05	0.04	6E-06

NOTES:

NA Not available
ND Not Determined due to lack of available information
lwa lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime excess Cancer Risk
\- the one hit equation for high carcinogenic risk was used to calculate the resident lwa and worker ILCR

Table 10.2.22
Hazard Quotients and Incremental Lifetime Cancer Risks
Dermal Contact With Surface Soil
SWMU 47 and AOC 516 Zone C
Naval Base Charleston
Charleston, SC

Chemical	Dermal Adjustment	Oral RfD Used (mg/kg-day	Oral SF Used (mg/kg-day)-1	Potential Future Resident adult Hazard Quotient	Potential Future Resident child Hazard Quotient	Potential Futu Resident lwa ILCR	Potential Curren Worker adult Hazard Quotient	Potential Current Worker adult ILCR
Benzo(a)pyrene Equiv	0.5	NA	14.6	ND	ND	6.9E-06	ND	2.8E-06
Aluminum	0.2	0.2	NA	0.002	0.008	ND	0.002	ND
Arsenic	0.2	6E-05	7.5	0.01	0.04	3.7E-06	0.01	1.5E-06
Beryllium	0.2	0.001	21.5	0.00001	0.00005	2.0E-07	0.00001	8.2E-08
Copper	0.2	0.008	NA	0.001	0.005	ND	0.001	ND
Lead	0.2	NA	NA	ND	ND	ND	ND	ND
Manganese	0.2	0.0094	NA	0.001	0.003	ND	0.0007	ND
Thallium	0.2	1.6E-05	NA	0.004	0.01	ND	0.003	ND
SUM Hazard Index/ILCR				0.02	0.1	1E-05	0.02	4E-06

NOTES:

NA Not available
ND Not Determined due to lack of available information
lwa lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime excess Cancer Risk
\- Dermal to absorbed dose adjustment factor is applied to adjust for Oral SF and RfD (i.e., the oral RfD is based on oral absorption efficiency which should not be applied to dermal exposure and dermal CDI)

areas. Locations 047SB005 and 047SB016, where the maximum BEQ concentrations were reported, are within small grassy areas. Current site users would be expected to have limited opportunity for exposure to affected surface soil in these areas. As a result, the risk/hazard projections discussed above are considered overestimates should existing site features be maintained under future use scenarios.

Lead Toxicity — Soil

At SWMU 47, one surface soil sample (047SB00701 1,120 mg/kg) contained lead at a concentration exceeding the residential cleanup goal of 400 mg/kg. The mean lead concentration at SWMU 47 was calculated to be 112 mg/kg. An area of concentrated impact was identified as represented by borings 047007, 516,001, and 516002. This area encompasses approximately one-half acre, and is considered to delineate the reasonable maximum exposure area. The mean lead concentration for these three locations is 385 mg/kg; which is below the residential goal. Because the hot-spot mean falls below the residential cleanup goal, chronic soil pathway exposures are not expected to pose a significant health threat to potential future child residents.

Groundwater Pathways

Exposure to shallow groundwater onsite was evaluated under both residential and industrial scenarios. The ingestion exposure pathway was evaluated assuming that site groundwater will be used for potable and/or domestic purposes and that an unfiltered well, drawing from the corresponding water-bearing zone, will be installed. For noncarcinogenic contaminants evaluated relative to future site residents, hazard was computed separately for child and adult receptors. Table 10.2.23 presents the risk and hazard for the exposure pathway.

Table 10.2.23
Hazard Quotients and Incremental Lifetime Cancer Risks
Shallow Groundwater Ingestion
SWMU 47 and AOC 516 Zone C
Naval Base Charleston
Charleston, SC

Chemical	Oral RfD Used (mg/kg-day)	Oral SF Used (mg/kg-day)-1	Potential Future Resident adult Hazard Quotient	Potential Future Resident child Hazard Quotient	Potential Futur Resident lwa ILCR	Potential Future Worker adult Hazard Quotient	Potential Future Worker adult ILCR
Arsenic	0.0003	1.5	4.2	9.9	1.0E-03	1.5	3.3E-04
SUM Hazard Index/ILCR			4	10	1.0E-03	2	3.3E-04

NOTES:

NA Not available
ND Not Determined due to lack of available information
lwa lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime excess Cancer Risk
- The one-hit equation for high carcinogenic risk levels was used for 3,3-Dimethylbenzidine resident lwa ILCR calculations

Hypothetical Site Residents

For the ingestion pathway, the lifetime weighted average ILCR was computed to be 1E-3. 3,3'-Dimethylbenzidine and arsenic are the sole contributors. HQ for the adult and child resident are 4 and 10 for the ingestion pathway. Arsenic was the sole contributor for both receptor groups.

Hypothetical Site Workers

For the ingestion pathway, the ILCR was computed to be 3E-4. Arsenic was the sole contributor. The ingestion pathway HI was computed to be 2 based on arsenic.

Current Site Workers

Shallow groundwater is not currently used as a potable water source for SWMU 47, or other areas of Zone C. In the absence of a completed exposure pathway, no threat to human health is posed by reported shallow groundwater contamination.

Lead Toxicity — Groundwater

As discussed in Section 10.2.6.2, first round groundwater results suggested gross contamination of the shallow aquifer. The results of subsequent sampling, however, led to the conclusion that first quarter results were anomalous and not representative of true aquifer quality. In fact, the four-quarter mean lead concentration in each well was found to be less than the 15 μg/L TTAL. As a result, existing lead levels are considered protective of human health and no formal analysis was warranted.

COCs Identified

COCs were identified based on cumulative (all pathway) risk and hazard projected for this site. USEPA has established a generally acceptable risk range of 1E-4 to 1E-6, and a HI threshold of 1.0 (unity). In this HHRA, a COC was considered to be any chemical contributing to a cumulative risk level of 1E-6 or greater and/or a cumulative HI above 1.0, and whose individual

ILCR exceeds 1E-6 or whose HQ exceeds 0.1. For carcinogens, this approach is relatively conservative, because a cumulative risk level of 1E-4 (and individual ILCR of 1E-6) is recommended by USEPA Region IV as the trigger for establishing COCs. The COC selection method presented was used to provide a more comprehensive evaluation of chemicals contributing to carcinogenic risk or noncarcinogenic hazard during the remedial goal options development process. Table 10.2.24 summarizes of COCs identified in each medium based on contribution to cumulative ILCR or HI.

Surface Soils

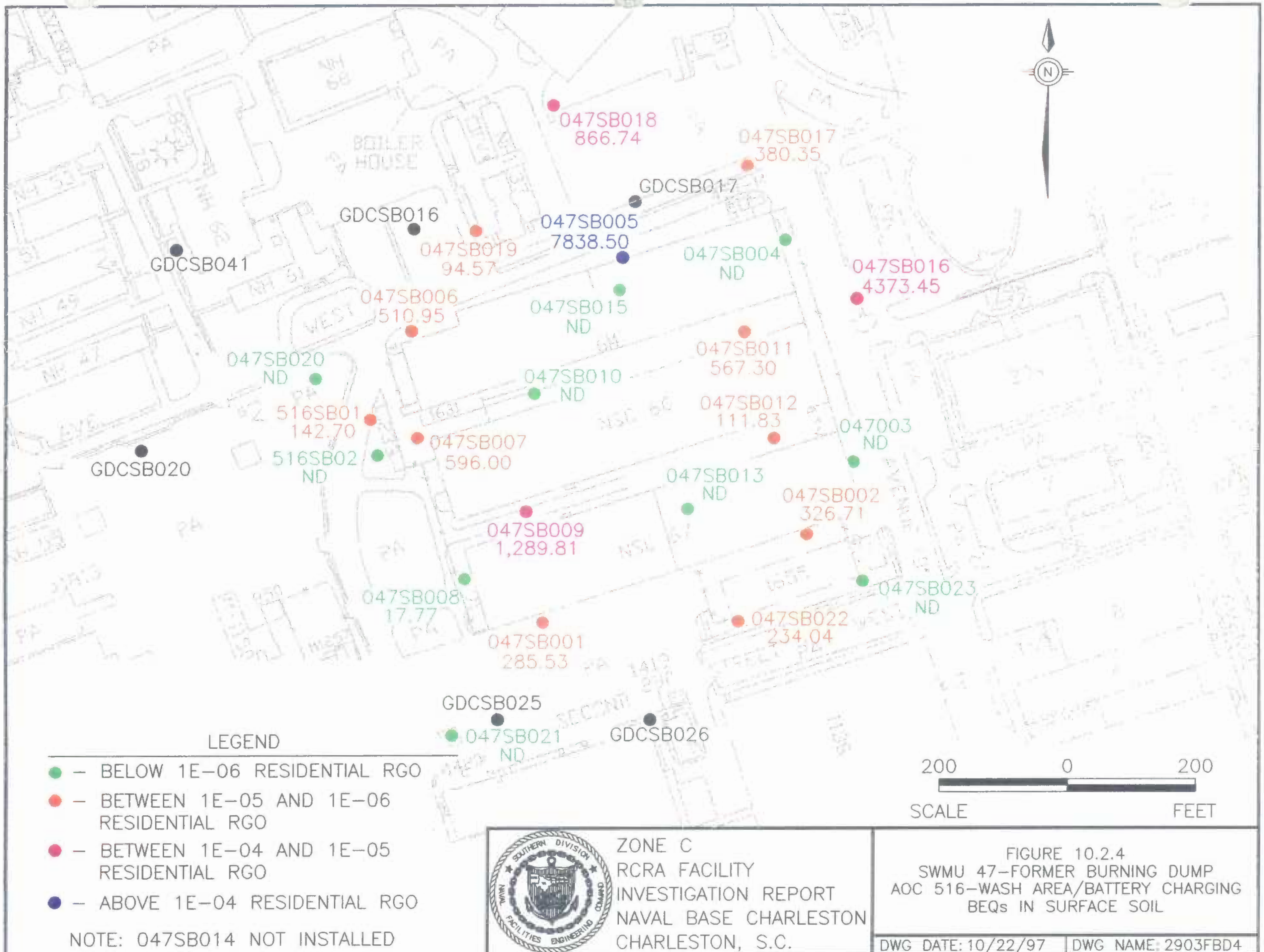
Hypothetical Site Residents (Future Land Use)

BEQs, arsenic, beryllium, and thallium were identified as COCs based on their contribution to cumulative ILCR and/or hazard. BEQs and arsenic in surface soil are shown on Figures 10.2.4 and 10.2.5.

Hypothetical Site Workers (Current Land Use)

BEQs and arsenic were identified as COCs based on their contribution to cumulative ILCR and/or hazard.

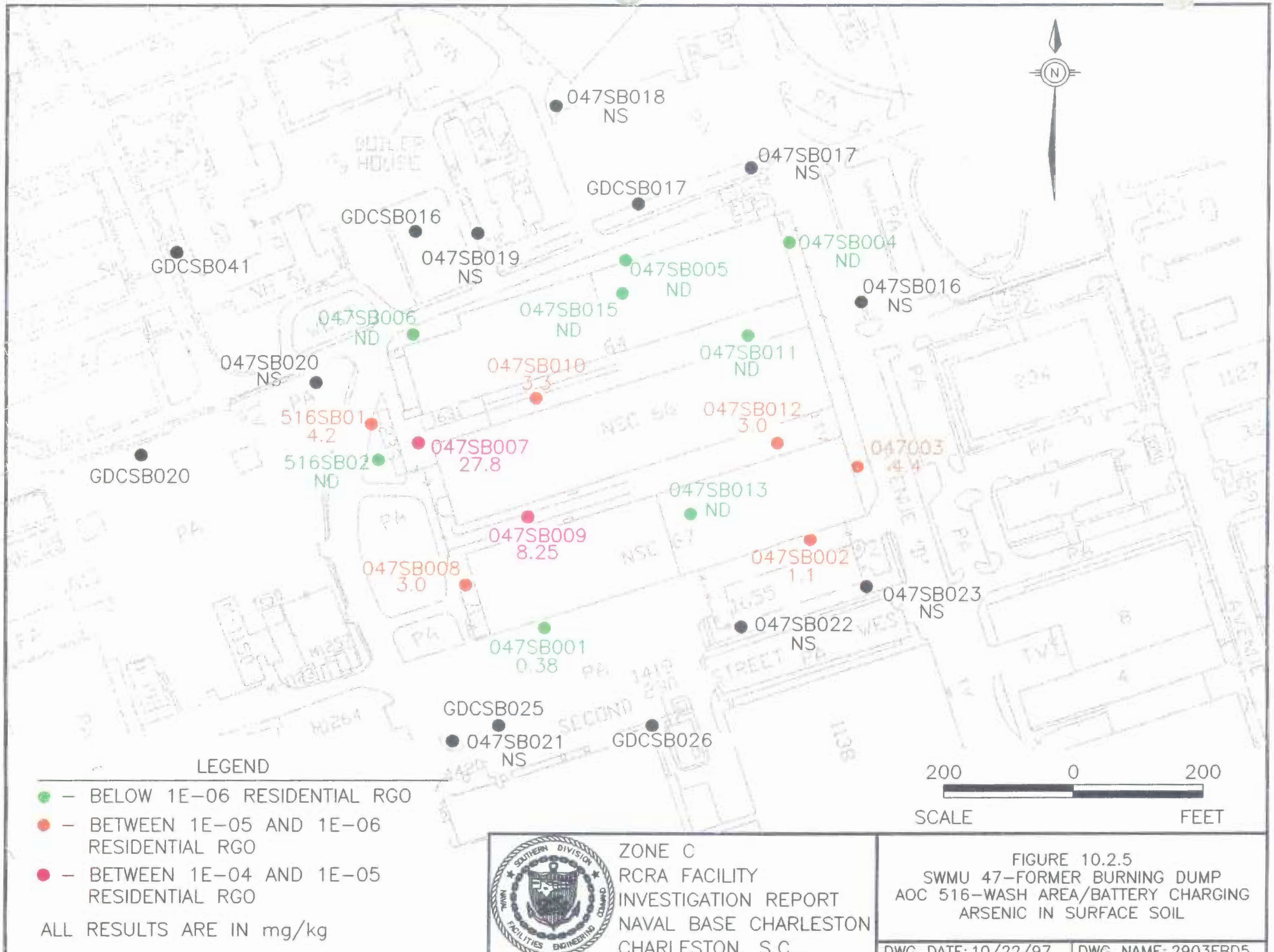
Aluminum and arsenic were detected in soil throughout SWMU 47. The mean concentrations for these elements were, however, less than their respective background reference concentrations. Beryllium was detected in three of 16 surface soil samples with a maximum concentration of 0.5 mg/kg. The calculated beryllium UCL (0.267 mg/kg) is comparable to the four beryllium detections reported at Zone C background locations. Thallium was detected at only one surface soil sampling location at a concentration of 2.1 mg/kg. Its absence at other locations indicates that the potential for chronic exposure is low.



ZONE C
RCRA FACILITY
INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 10.2.4
SWMU 47–FORMER BURNING DUMP
AOC 516–WASH AREA/BATTERY CHARGING
BEQs IN SURFACE SOIL

DWG DATE: 10/22/97 | DWG NAME: 2903FBD4



ZONE C
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NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 10.2.5
SWMU 47–FORMER BURNING DUMP
AOC 516–WASH AREA/BATTERY CHARGING
ARSENIC IN SURFACE SOIL

DWG DATE: 10/22/97 | DWG NAME: 2903FBD5

Table 10.2.24
Summary of Risk and Hazard-based COCs for SWMU 47 and AOC 516
NAVBASE - Charleston Zone C
Charleston, South Carolina

Medium	Exposure Pathway		Potential Futu Resident Adul Hazard Quoti	Potential Futu Resident Chil Hazard Quoti	Potential Future Resident lwa ILCR	Site Worker Hazard Quoti	Site Worker ILCR	Identification of COCs			
Surface Soil	Incidental Ingestion	Benzo(a)pyrene Eq	ND	ND	1.5E-05	ND	1.7E-06		2		4
		Aluminum	0.01	0.1	ND	0.004	ND	1			
		Arsenic	0.1	0.6	3.3E-05	0.02	3.6E-06	1	2		4
		Beryllium	0.00007	0.0007	1.8E-06	0.00003	2.0E-07		2		
		Copper	0.01	0.07	ND	0.003	ND				
		Lead	ND	ND	ND	ND	ND				
		Manganese	0.005	0.05	ND	0.002	ND				
		Thallium	0.02	0.2	ND	0.006	ND	1			
	Dermal Contact	Benzo(a)pyrene Eq	ND	ND	6.9E-06	ND	2.8E-06		2		4
		Aluminum	0.002	0.008	ND	0.002	ND				
		Arsenic	0.01	0.04	3.7E-06	0.01	1.5E-06		2		4
		Beryllium	0.00001	0.00005	2.0E-07	0.00001	8.2E-08				4
		Copper	0.001	0.005	ND	0.001	ND				
		Lead	ND	ND	ND	ND	ND				
		Manganese	0.0010	0.003	ND	0.0007	ND				
		Thallium	0.004	0.01	ND	0.003	ND				
Surface Soil Pathway Sum			0.13	1.0	6E-05	0.053	1E-05				
Shallow Groundw	Ingestion										
		Arsenic	4.2	9.9	1.0E-03	1.5	3.3E-04	1	2	3	4
Shallow Groundwater Pathway Sum			4	10	1E-03	2	3E-04				
Sum of All Pathways			4	11	1E-03	2	3E-04				

Notes:
ND indicates not determined due to the lack of available risk information.
ILCR indicates incremental excess lifetime cancer risk
HI indicates hazard index
1- Chemical is a COC by virtue of projected child residence non-carcinogenic hazard.
2- Chemical is a COC by virtue of projected future resident lifetime ILCR.
3- Chemical is a COC by virtue of projected site worker non-carcinogenic hazard.
4- Chemical is a COC by virtue of projected site worker ILCR.

The highest BEQ concentrations were reported at locations 047SB005 (7.648 mg/kg) and 047SB016 (4.373 mg/kg). Both samples were collected from small patches of grass-covered soil amidst buildings and roadways near Buildings NSC-64, NSC-66, and NSC-67. BEQ concentrations in excess of 0.5 mg/kg were reported throughout the SWMU 47 area. As a result, chronic exposure to BEQs at concentrations above residential and industrial RBCs is possible for individuals working or residing in this area.

Groundwater

Hypothetical Site Residents (Future Land Use)

Arsenic was identified as the only COC for this scenario based on the sum ILCR and HI. Arsenic concentrations in Zone C shallow groundwater are shown on Figure 10.1.7.

Hypothetical Site Workers (Current Land Use)

Arsenic was identified as the only COC for this scenario based on the sum ILCR and HI.

Due to the limited extent of identified shallow groundwater impacts, graphical presentation of risk projections for SWMU 47 shallow groundwater would be of limited use. Alternatively, the extent of each COC is briefly discussed below. Arsenic concentrations were generally consistent throughout SWMU 47, with the sample from well 047011 (46.3 μg/L) having the only concentration above 9.2 μg/L. Although former site operations (lead-acid batter recharging) could be a potential source of heavy metals, monitoring well 047007 did not have significantly elevated arsenic concentrations. It is possible that reported shallow groundwater concentrations in the two principal metals-impacted wells could be associated with entrained sediment. Subsequent quarterly sampling results corroborated the relatively dramatic arsenic impacts in well 047011.

10.2.6.6 Risk Uncertainty

Characterization of Exposure Setting and Identification of Exposure Pathways

The potential for high bias is introduced through the exposure setting and pathway selection due to the highly conservative assumptions (i.e., future residential use) recommended by USEPA Region IV when assessing potential future and current exposure. The exposure assumptions made in the site worker scenario are highly protective and would tend to overestimate exposure. Most of the area impacted by COPCs is covered by buildings or an asphalt surface, precluding exposure to underlying affected surface soil. BEQ concentrations in excess of 1 mg/kg were, however, reported in small grassy areas around Building NSC-64 and in a median strip in an adjacent parking area. As a result, limited exposure to these maximally impacted areas is possible, although the frequency and duration of direct contact are likely quite low. Current site workers are not exposed to site groundwater.

Residential use of the site is not expected, based on current site uses and the nature of surrounding buildings. Current base reuse plans call for SWMU 47 to become a parking lot. Nearby properties may be developed for office/training support, community support, and potentially housing. If this area were to be used as a residential site, the buildings would be demolished, asphalt surface removed, and the surface soil conditions would likely change dramatically — the soil could be covered with landscaping soil and/or a house. Consequently, exposure to current surface soil conditions would not be likely under a true future residential scenario. These factors indicate that exposure pathways assessed in this HHRA would generally overestimate the risk and hazard posed to current site workers and future site residents. If only minimal site regrading or filling were to be performed during residential development, the concentrations of many surface soil contaminants, most notably BEQs, could pose an unacceptable threat to residents' health assuming chronic exposure to limited impacted areas.

Shallow groundwater is not currently used at SWMU 47 for potable or industrial purposes. A basewide system provides drinking and process water to buildings throughout Zone C. This system is scheduled to remain in operation under the current base reuse plan. As a result, shallow groundwater would not be expected to be used under future site use scenarios. Therefore, the scenario established to project risk/hazard associated with shallow groundwater exposure is highly conservative, and associated pathways are not expected to be completed in the future.

Determination of Exposure Point Concentrations

Dependent upon the distribution of soil COPCs, different methods were applied to establish soil EPCs. Due to the widespread detection of benzo(a)pyrene equivalents, aluminum, and beryllium above screening values, UCLs were applied to EPCs. Arsenic, copper, manganese, and thallium were detected in only a small portion of the site at elevated levels. As a result, the maximum detected concentration or the mean of results within the maximally impacted area was used as the EPC.

The maximum first-quarter arsenic result was used as the EPC for groundwater arsenic. This result was reported in well 047011. During subsequent quarters, arsenic concentrations in this well rose to a maximum of 164 μg/L (second quarter), which also exceeds the MCL. Based on this information, risk and hazard may have been underestimated.

Frequency of Detection and Spatial Distribution

BEQs were detected in 13 surface soil samples at concentrations in excess of the residential RBC. These detections are widely distributed across the site, indicating that chronic exposure to BEQ concentrations of concern is possible. Aluminum, arsenic, copper, lead, manganese, and thallium were detected in only one or two surface soil samples above the residential RBC and respective background reference concentrations. Based upon their limited frequency of detection at elevated levels, a hot-spot approach was used to estimate exposure to each of these elements. An FI/FC term of 0.5 was used to adjust the EPCs for arsenic, manganese, and thallium to reflect an impacted area of one-quarter acre or less (of a 0.5-acre exposure area). Copper was detected at elevated levels in samples representing approximately one-half acre; thus an FI/FC of 1 was applied. The UCLs for aluminum and arsenic are all below background reference concentrations.

Beryllium was reported in only three of 16 samples analyzed, with a maximum concentration of 0.5 mg/kg. The beryllium UCL concentration (0.267 mg/kg) is comparable to the four detections reported in Zone C background reference samples.

The maximum lead (467 μg/L) and antimony (53.1 μg/L) groundwater concentrations were reported in monitoring well 047001 first-quarter samples. This well is south of Building NSC-67, approximately 100 yards southeast of the lead-acid battery recharging area (AOC 516). Although AOC 516 would be a suspected source of heavy metals, monitoring well 047007, which is within 30 feet of the battery recharging facility, did not exhibit any significant impacts. Subsequent quarterly results indicated that initial data were anomalous, and these parameters were excluded from formal assessment.

Aluminum, manganese, tetrachloroethene (PCE), and thallium were excluded from the formal groundwater assessment. The basis for their exclusion was absence during first-quarter sampling at concentrations above screening values. Aluminum, manganese, and PCE were detected on an isolated basis but assessment of temporal data did not suggest the potential for chronic exposure at significant levels (above RBCs and/or reference concentrations). Thallium was also detected sporadically in second, third, and fourth-quarter samples. Results (qualitative or quantitative) were never confirmed in consecutive quarters. Although omission of these parameters could result in an underestimation of risk or hazard, their inconsistent detection indicated little potential for chronic exposure.

Arsenic was detected in five shallow groundwater samples with a maximum concentration of 46.3 μg/L in the sample from 047011. This well is between Buildings NSC-64 and NSC-66. Well 047011 was the only location at which arsenic concentrations were consistently above background reference levels. TPH (DRO and GRO) were detected in samples from two monitoring wells. DRO were detected at 0.13 mg/L in sample 047GW01001 and GROs were detected at 0.66 mg/L in sample 047GW01301.

3,3'-Dimethylbenzidine was detected in one shallow groundwater sample (047GW00501, 0.1 mg/L). Because benzidines are common components of coal tar, asphalt, and partially combusted petroleum products, it has been hypothesized that the detection reported from well 047005 may be associated with sediment/soil entrained in the borehole annular space during well installation. Second, third, and fourth-quarter results corroborated this suspicion and 3,3'-dimethylbenzidine was excluded from formal assessment.

Quantification of Risk/Hazard

As indicated by the discussions above, the uncertainty inherent in the risk assessment process is great. In addition, many site-specific factors have affected the uncertainty of this assessment that would upwardly bias the risk and hazard estimates. Exposure pathway-specific sources of uncertainty are discussed below.

Soil

Of the CPSSs screened and eliminated from formal assessment, none was reported at a concentration close to its corresponding RBC (i.e., within approximately 10% of the RBC). This minimizes the likelihood of potentially significant cumulative risk/hazard based on the eliminated CPSSs. There were no inorganic parameters that exceeded their RBCs, but not corresponding reference concentration.

Central tendency analysis was not formally performed for SWMU 47 surface soil, but a simplified approach was taken to assess the potential influences of CT assumptions. The central tendency assumption for residential exposure duration is nine years compared to the 30-year assumption for RME. The CT exposure frequency assumption is 234 days/year compared to 350 days/year RME. In addition, CT ingestion rate assumptions are one-half those applied for RME. If all other exposure assumptions remain fixed, application of the CT exposure duration and frequency, as well as ingestion rate would result in risk projections approximately 90% below the RME. At CT, the residential surface soil pathway related risk (incidental ingestion and dermal contact) would be approximately 6E-6, but would still exceed the 1E-6 point of departure. The child resident surface soil pathway-related HQ would, however, fall farther below 1 under CT assumptions, and no noncarcinogenic COCs would be identified for SWMU 47.

Although the future land use of SWMU 47 is unknown, both the worker and residential exposure scenarios were assessed in this HHRA. Current base reuse plans call for conversion of the area to a parking lot. As previously discussed, it is likely that these scenarios would lead to overestimates of risk and/or hazard.

Groundwater

Of the CPSSs screened and eliminated from formal assessment, none was reported at a concentration close to its corresponding RBC (i.e., within approximately 10% of the RBC). No inorganic parameters were eliminated from formal assessment based strictly upon comparison to background reference concentrations.

Arsenic was detected throughout SWMU 47 in the shallow aquifer, however all concentrations were below the MCL (50 μg/L).

Groundwater is not currently used as a potable water source at SWMU 47, because municipal water is readily available. As previously mentioned, it is highly unlikely that the site will be developed as a residential area, and it is unlikely that a potable-use well would be installed onsite. It is probable that, if residences were constructed onsite and an unfiltered well were installed, the salinity and dissolved solids would preclude this aquifer from being an acceptable potable water source.

10.2.6.7 Risk Summary

The risk and hazard posed by contaminants at SWMU 47 were assessed for the hypothetical site worker and the hypothetical future site resident under reasonable maximum exposure assumptions. For surface soils, the incidental ingestion and dermal contact pathways were assessed in this HHRA. The ingestion pathway was evaluated for shallow groundwater. Table 10.2.25 summarizes risk for each pathway/receptor group evaluated for SWMU 47.

10.2.6.8 Remedial Goal Options

Soil

Surface soil RGOs for carcinogens presented in Tables 10.2.26 and 10.2.27 were based on the lifetime weighted average site resident and adult site worker, respectively. Hazard-based RGOs were calculated based on either the hypothetical child resident or the adult site worker, as noted in each of the corresponding tables.

Groundwater

Shallow groundwater RGOs based on site residents and site workers are shown in Table 10.2.28 and 10.2.29, respectively. The maximum SWMU 47 shallow groundwater arsenic concentration (46.3 μg/L) does not exceed the MCL of 50 μg/L.

Table 10.2.25
Summary of Risk and Hazard for SWMU 47 and AOC 516
NAVBASE - Charleston Zone I
Charleston, South Carolina

Medium	Exposure Pathway	HI (Adult)	HI (Child)	ILCR (LWA)	HI (Worker)	ILCR (Worker)
Surface Soil	Incidental Ingestion	0.10	1.0	5E-05	0.04	6E-06
	Dermal Contact	0.021	0.1	1E-05	0.02	4E-06
Shallow Groundwater	Ingestion	11	26	2E-02	4	5E-03
Sum of All Pathways		11	27	2E-02	4	5E-03

Notes:
ND indicates not determined due to the lack of available risk information.
ILCR indicates incremental excess lifetime cancer risk
HI indicates hazard index

Table 10.2.26
Residential-Based Remedial Goal Options Surface Soil
SWMU 47 and AOC 516 Zone C
Naval Base Charleston
Charleston, South Carolina

				Hazard-Based Remedial Goal Option			**Risk-Based Remedial Goal Option**			
Chemical	Slope Factor (mg/kg-day)-1	Reference Dose (mg/kg-day)	Unadjusted EPC mg/kg	**3** mg/kg	**1** mg/kg	**0.1** mg/kg	**1E-06** mg/kg	**1E-05** mg/kg	**1E-04** mg/kg	Background Concentration mg/kg
Benzo(a)pyrene Equiv	7.3	NA	1.351	ND	ND	ND	0.06	0.6	6	NA
Aluminum	NA	1	8143.1	218781	72927	7293	ND	ND	ND	9990
Arsenic	1.5	0.0003	27.8	131	43.8	4.4	0.77	7.7	77	14.2
Beryllium	4.3	0.005	0.267	1094	365	36.5	0.13	1.3	13	ND
Copper	NA	0.04	208	8751	2917	292	ND	ND	ND	34.7
Lead	NA	NA	385	ND	ND	ND	ND	ND	ND	330
Thallium	NA	8E-05	2.1	35.0	11.7	1.17	ND	ND	ND	ND

NOTES:

EPC exposure point concentration
NA not applicable
ND not determined
- remedial goal options were based on the residential lifetime weighted average for carcinogens and the child resident for noncarcinogens

Table 10.2.27
Worker-Based Remedial Goal Options Surface Soil
SWMU 47 and AOC 516 Zone C
Naval Base Charleston
Charleston, South Carolina

				Hazard-Based Remedial Goal Option			**Risk-Based Remedial Goal Option**			
Chemical	Slope Factor (mg/kg-day)-1	Reference Dose (mg/kg-day)	Unadjusted EPC mg/kg	**3** mg/kg	**1** mg/kg	**0.1** mg/kg	**1E-06** mg/kg	**1E-05** mg/kg	**1E-04** mg/kg	Background Concentration mg/kg
Benzo(a)pyrene Equiv	7.3	NA	1.351	ND	ND	ND	0.30	3.0	30	NA
Arsenic	1.5	0.0003	27.8	ND	ND	ND	5.41	54.1	541	24.96

NOTES:

EPC exposure point concentration
NA not applicable
ND not determined

Table 10.2.28
Residential-Based Remedial Goal Options Shallow Groundwater
SWMU 47 and AOC 516 Zone C
Naval Base Charleston
Charleston, South Carolina

Chemical	Oral SF (mg/kg-day)	Oral RfD (mg/kg-day	Unadj. EPC mg/l	Hazard-Based Remedial Goal Optio 0.1 mg/l	1.0 mg/l	3 mg/l	Risk-Based Remedial Goal Options 1E-06 mg/l	1E-05 mg/l	1E-04 mg/l	ARAR mg/l	Background Concentration mg/l
Arsenic	1.5	0.0003	0.046	0.0005	0.005	0.01	0.00004	0.0004	0.004	0.05	0.0061

NOTES:

EPC exposure point concentration
NA not applicable
ND not determined
- remedial goal options were based on the residential lifetime weighted average for carcinogens and the child resident for noncarcinogens

Table 10.2.29
Worker-Based Remedial Goal Options Shallow Groundwater
SWMU 47 and AOC 516 Zone C
Naval Base Charleston
Charleston, South Carolina

Chemical	Oral SF (mg/kg-day)	Oral RfD (mg/kg-day	Unadj. EPC mg/l	Hazard-Based Remedial Goal Optio 0.1 mg/l	1 mg/l	3 mg/l	Risk-Based Remedial Goal Options 1E-06 mg/l	1E-05 mg/l	1E-04 mg/l	ARAR mg/l	Background Concentration mg/l
Arsenic	1.5	0.0003	0.0463	0.003	0.03	0.09	0.0001	0.001	0.01	0.05	ND

NOTES:

EPC exposure point concentration
NA not applicable
ND not determined

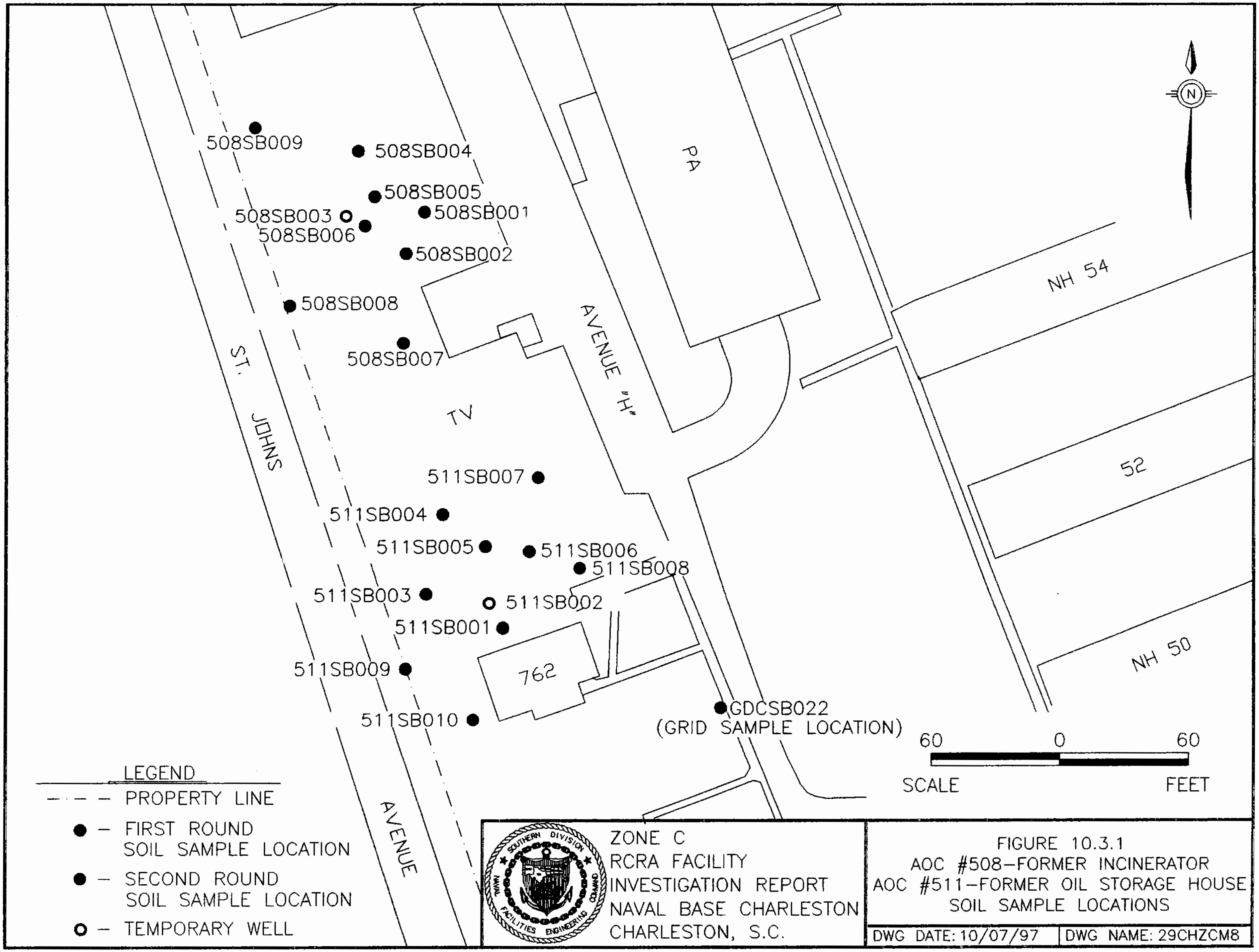
10.3 AOC 508 — Former Incinerator, and AOC 511 — Former Oil Storage House

An incinerator operated at AOC 508 from 1922 until 1929. Its exact dimensions and operating practices are unknown. Currently this site is a grass-covered area less than 75 by 75 feet along Avenue H, north of Building 762 (Figure 10.3.1). Potential contaminants include petroleum hydrocarbons, metals, and residues of incomplete combustion. AOC 511 was an oil storehouse which operated from 1922 until late 1954. The size of the storage house and the operating procedures are unknown. This site is also a small grass-covered area between AOC 508 and Building 762 (Figure 10.3.1). Potential contaminants include petroleum hydrocarbons. A CSI was completed at AOCs 508 and 511 to identify impacts to soil resulting from releases of former site operations. Groundwater was not included in this CSI as outlined in the *Zone C RFI Work Plan* (E/A&H November 1995).

10.3.1 Soil Sampling and Analysis

Soil was sampled in accordance with the *Final Zone C RFI Work Plan* (E/A&H, November 1995) and Section 3 of this report. Figure 10.3.1 shows sampling locations for each site. Sampling locations were selected following a review of historic maps of each area and targeting the locations most likely to have been impacted if a release had occurred.

Soil was sampled in two rounds. During the first round of sampling, samples were collected from six location at each site. Eighteen samples were collected in all during the first round, 12 from the upper interval and six from the lower interval. Samples were analyzed for VOCs, SVOCs, pesticide/PCBs, metals, cyanide, and TPH at DQO Level III. Two duplicate soil samples were submitted for Appendix IX analyses at DQO Level IV, which includes the parameters listed above as well as herbicides, hexavalent chromium, organophosphorous pesticides, and dioxins. Table 10.3.1 summarizes the first-round soil sampling and analysis.



ZONE C
RCRA FACILITY
INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 10.3.1
AOC #508–FORMER INCINERATOR
AOC #511–FORMER OIL STORAGE HOUSE
SOIL SAMPLE LOCATIONS

DWG DATE: 10/07/97 | DWG NAME: 29CHZCM8

Table 10.3.1
AOC 508 — Former Incinerator/AOC 511 — Oil Storage House
First Round — Soil Sampling and Analysis

Interval	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
Upper	12	12	Standard Suite[a], TPH	Standard Suite[a], TPH	None
Lower	6	6	Standard Suite[a], TPH	Standard Suite[a], TPH	Shallow water table; saturated samples were not submitted for analyses

Note:
[a] = Standard Suite includes VOCs, SVOCs, metals, cyanide, and pesticide/PCBs.

First-round soil data were compared to the USEPA Region III *Risk-Based Concentration Tables*; June 1996. This preliminary review indicated SVOCs exceed their RBCs in upper interval samples from locations 508SB003, 508SB005, and 508SB006, and that 4,4-DDT was detected above its RBC in the upper interval from 508SB003. Based on this preliminary review, seven upper interval soil samples (three at 508 and four at 511) were collected from seven additional locations west, northwest, and southwest (Figure 10.3.1). The sample locations were selected to delineate the extent of SVOCs and 4,4-DDD. The additional samples were analyzed for SVOCs, pesticides/PCBs and metals at DQO Level III. Second-round sampling and analysis is in Table 10.3.2.

Table 10.3.2
AOC 508 — Former Incinerator/AOC 511 — Oil Storage House
Second Round — Soil Sampling and Analysis

Interval	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
Upper	0	7	SVOCs, metals, pesticides/PCBs	SVOCs, metals, pesticides/PCBs	Added
Lower	0	0	None	None	None

10.3.2 Nature and Extent of Soil Contamination

Soil analytical results for organic compounds are in Table 10.3.3, and results of inorganic results are in Table 10.3.4. The complete analytical report is in Appendix D, and Appendix H contains detection only summary tables.

Table 10.3.3
AOC 508 — Former Incinerator/AOC 511 — Oil Storage House
Organic Compound Analytical Results for Soil

Compound	Sample Interval	Frequency of Detection	Range of Detection	Mean	RBC[a]	Number Samples Exceeding RBC
Volatile Organic Compounds (µg/kg) **(Upper Interval — 12 Samples plus 1 Duplicate/Lower interval — 6 Samples plus 1 Duplicate)**						
Acetone	Upper	1/12	39.0	NA	780,000	0
	Lower	1/6	20.0	NA	800	0
Toluene	Upper	5/12	1.0 - 8.0	3.600	1,600,000	0
Semivolatile Organic Compounds (µg/kg) **(Upper Interval — 19 Samples plus 1 Duplicate/Lower interval — 6 Samples plus 1 Duplicate)**						
Acenaphthylene	Upper	3/19	53.0 - 110.0	88.170	47,000	0
Anthracene	Upper	2/19	43.0 - 50.0	46.500	2,300,000	0
Benzo(a)anthracene	Upper	8/19	41.0 - 910	279.60	880[b]	1
Benzo(a)pyrene	Upper	8/19	45.0 - 1,100	309.75	88[b]	4
Benzo(b)fluoranthene	Upper	9/19	69.0 - 1,700	463.78	880[b]	2
Benzo(g,h,i)perylene	Upper	4/19	41.0 - 470	252.75	230,000	0
Benzo(k)fluoranthene	Upper	9/19	38.0 - 1,900	447.00	8,800[b]	0
Bis(2-ethylhexyl) phthalate	Upper	6/19	72.0 - 160	102.00	46,000	0
Chrysene	Upper	10/19	39.0 - 880	253.40	8,800[b]	0
1-Methylnaphthalene	Upper	1/19	100	100.00	310,000	0
2-Methylnaphthalene	Upper	1/19	120.0	120.00	310,000	0
Dibenzo(a,h)anthracene	Upper	2/19	90.5 - 120.0	105.25	88[b]	2
Fluoranthene	Upper	11/19	36.0 - 980	272.91	310,000	0
Indeno(1,2,3-cd)pyrene	Upper	4/19	37.0 - 450	234.25	88[b]	0

Table 10.3.3
AOC 508 — Former Incinerator/AOC 511 — Oil Storage House
Organic Compound Analytical Results for Soil

Compound	Sample Interval	Frequency of Detection	Range of Detection	Mean	RBC[a]	Number Samples Exceeding RBC
Naphthalene	Upper	1/19	84.0	84.00	310,000	0
Phenanthrene	Upper	5/19	41.0 - 245	112.60	230,000	0
Pyrene	Upper	10/19	39.0 - 1300	308.60	230,000	0
BEQ	Upper	10/19	0.043 - 1,545.88	346.60	88	5
Pesticide and PCB Compounds (μg/kg) **(Upper Interval — 19 Samples plus 1 Duplicate/Lower interval — 6 Samples plus 1 Duplicate)**						
Aldrin	Upper	2/19	1.0 - 3.3	2.150	38	0
beta-BHC	Upper	4/19	1.7 - 6.0	2.900	350	0
4,4-DDD	Upper	12/19	1.8 - 350.0	51.217	2,700	0
4,4-DDE	Upper	13/19	11.0 - 1,200.0	258.6	1,900	0
	Lower	3/6	4.6 - 5.0	4.800	500	0
4,4-DDT	Upper	14/19	17.0 - 2,700.0	362.071	1,900	1
	Lower	2/6	5.6 - 7.5	6.550	1,000	0
Chlordane	Upper	11/15	11.0 - 520.0	131.91	490	1
	Lower	1/5	4.2	4.2	2000	0
delta-BHC	Upper	4/19	3.2 - 34.0	13.625	350	0
Dieldrin	Upper	12/19	0.72 - 200.0	24.277	40	1
	Lower	1/4	20.0	20.0	1	1
Endosulfan I	Upper	5/19	0.98 - 6.7	3.410	47,000	0
Endosulfan II	Upper	5/19	4.4 - 11.0	7.420	47,000	0
Endosulfan sulfate	Upper	3/19	2.6 - 4.7	3.470	47,000	0
Endrin	Upper	7/19	0.240 - 55.0	18.020	2,300	0
Endrin aldehyde	Upper	7/19	0.540 - 3.40	1.606	2,300	0
gamma-BHC	Upper	1/19	2.6	2.600	490	0
Heptachlor	Upper	1/19	1.7	NA	140	0
Heptachlor epoxide	Upper	13/19	0.24 - 45.0	10.580	70	0
Methoxychlor	Upper	9/19	1.10 - 94.0	24.767	39,000	0

Table 10.3.3
AOC 508 — Former Incinerator/AOC 511 — Oil Storage House
Organic Compound Analytical Results for Soil

Compound	Sample Interval	Frequency of Detection	Range of Detection	Mean	RBC[a]	Number Samples Exceeding RBC
Herbicides (μg/kg) **(Upper Interval — 1 Sample/Lower Interval 1 Sample)**						
2,4,5-Trichlorophenoxyacetate Acid	Upper	1/1	12.0	NA	78,000	0
Organophosphorous Pesticides (μg/kg) **(Upper Interval — 1 Sample/Lower Interval 1 Sample)**						
Phorate	Lower	1/1	3.7	NA	48	0
Dioxins (ng/kg) **(Upper Interval — 1 Sample / Lower Interval 1 Sample)**						
1234678-HpCDD	Upper	1/1	68.6	NA	NA	NA
	Lower	1/1	3.18	NA	NA	NA
123678-HxCDD	Upper	1/1	1.93	NA	NA	NA
1234678-HpCDF	Upper	1/1	37.2	NA	NA	NA
	Lower	1/1	1.7	NA	NA	NA
123478-HxCDF	Upper	1/1	5.446	NA	NA	NA
12378-PeCDF	Upper	1/1	0.466	NA	NA	NA
234678-HxCDF	Upper	1/1	1.07	NA	NA	NA
OCDD	Upper	1/1	511.9	NA	NA	NA
	Lower	1/1	22.32	NA	NA	NA
OCDF	Upper	1/1	59.58	NA	NA	NA
	Lower	1/1	4.11	NA	NA	NA
TDCC TEQ	Upper	1/1	0.0755	NA	1,000	0
	Lower	1/1	2.50	NA	80	0

Table 10.3.3
AOC 508 — Former Incinerator/AOC 511 — Oil Storage House
Organic Compound Analytical Results for Soil

Compound	Sample Interval	Frequency of Detection	Range of Detection	Mean	RBC[a]	Number Samples Exceeding RBC
Petroleum Hydrocarbon Analysis (Units mg/kg)						
TPH (IR)	Upper	12/12	16.5 - 746.0	209.66	100	6
	Lower	6/6	21.4 - 37.2	29.58	NA	0

Note:
[a] = Noncarcinogenic RBCs were adjusted to equateto a hazard quotient of 0.1.
[b] = These compounds are cPAHs and were multiplied by the appropriate BEF for comparison as BEQs.
All results are in μg/kg except for dioxins which are in nanograms per kilogram (ng/kg), and TPH which are in milligrams per kilogram (mg/kg).

Table 10.3.4
AOC 508 — Former Incinerator/AOC 511 — Oil Storage House
Inorganic Analytical Results for Soil

Compound	Sample Interval	Frequency of Detection	Range of Detection (mg/kg)	Mean (mg/kg)	Reference Conc. (mg/kg)	Number of Samples Exceeding Reference
Aluminum	Upper	19/19	2,240.0 - 5,150.0	4,041	9,990	0
	Lower	6/6	925 - 4,730	3,220	23,700	0
Antimony	Upper	10/19	0.20 - 0.70	0.38	0.55	2
Arsenic	Upper	11/19	1.1 - 4.4	2.39	14.2	0
	Lower	1/6	0.46	NA	14.1	0
Barium	Upper	19/19	6.40 - 122.0	33.66	77.2	1
	Lower	6/6	2.2 - 12.0	7.89	68.5	~~1~~ 0
Beryllium	Upper	9/19	0.08 - 0.22	0.13	ND	2
	Lower	5/6	0.03 - 0.08	0.064	0.98	0
Cadmium	Upper	8/19	0.10 - 0.69	0.416	0.65	1
Calcium	Upper	19/19	408.0 - 7,035.0	1,464.16	NA	0
	Lower	6/6	223.0 - 462.0	311.58	NA	0
Chromium	Upper	19/19	3.60 - 12.85	6.89	26.4	0
	Lower	6/6	1.4 - 6.2	4.06	12.5	0

Table 10.3.4
AOC 508 — Former Incinerator/AOC 511 — Oil Storage House
Inorganic Analytical Results for Soil

Compound	Sample Interval	Frequency of Detection	Range of Detection (mg/kg)	Mean (mg/kg)	Reference Conc. (mg/kg)	Number of Samples Exceeding Reference
Cobalt	Upper	19/19	0.21 - 1.50	0.63	3.22	0
	Lower	6/6	0.07 - 0.38	0.211	7.1	0
Copper	Upper	19/19	2.80 - 70.70	15.66	34.7	0
	Lower	5/6	0.41 - 2.40	1.09	42.2	0
Iron	Upper	19/19	1,000 - 11,700	3,334.7	NA	0
	Lower	6/6	532.0 - 2,490	1,767.0	NA	0
Lead	Upper	19/19	13.8 - 767.5	203.43	330	4
	Lower	6/6	1.40 - 25.40	8.8	73.2	0
Magnesium	Upper	19/19	112.0 - 665.5	259.40	NA	0
	Lower	6/6	30.8 - 188.0	104.56	NA	0
Manganese	Upper	19/19	8.20 - 73.85	30.71	92.5	0
	Lower	6/6	2.1 - 10.6	5.85	106	0
Mercury	Upper	11/19	0.10 - 0.40	0.23	0.24	5
	Lower	1/6	11.20	NA	0.30	1
Nickel	Upper	19/19	0.85 - 5.15	2.32	12.3	0
	Lower	5/6	0.22 - 1.20	0.79	16.7	0
Potassium	Upper	18/19	61.7 - 206.0	110.87	NA	0
	Lower	5/6	32.7 - 110.0	81.54	NA	0
Selenium	Upper	7/19	0.49 - 1.20	0.75	1.44	0
	Lower	1/6	0.45	NA	2.90	0
Tin	Upper	19/19	1.20 - 37.10	4.27	2.95	7
	Lower	5/6	1.00 - 1.40	1.2	2.37	0
Vanadium	Upper	19/19	3.00 - 10.90	6.62	23.4	0
	Lower	6/6	0.77 - 5.60	3.54	56.9	0
Zinc	Upper	19/19	19.80 - 251.0	96.05	159	4
	Lower	6/6	1.60 - 45.30	14.39	243	0

Volatile Organic Compounds in Soil

Toluene was detected in upper interval samples, and acetone was detected in one sample in both upper and lower interval samples. Both compounds were below their respective RBCs in the upper interval sample. Acetone was below the SSL in the lower interval sample.

Semivolatile Organic Compounds in Soil

Seventeen SVOCs were detected at the sites. Four compounds, all cPAHs, were detected above their respective RBCs. The BEQs exceeded the RBC of 88.0 μg/kg for BaP at five locations. The two highest BEQs were at locations 508SB003 and 508SB006.

Pesticides and PCBs in Soil

Sixteen pesticides were detected in the upper interval and two were detected in the lower interval. Two pesticides exceeded their respective RBCs, 4,4-DDT and dieldrin, in the upper interval. Lower interval samples were below their SSLs.

No PCBs were reported in the soil samples collected at AOCs 508 and 511.

Other Organic Compounds in Soil

Other organic compounds are the Appendix IX compound groups that are not part of the standard analytical suite, including herbicides, organophosphorous pesticides, and dioxins.

Total petroleum hydrocarbon was detected in six samples at concentrations above the arbitrary screening threshold of 100 mg/kg.

Only one herbicide, 2,4,5-trichlorophenoxyacetic acid (2,4-T), was detected at a concentration of 12.0 μg/kg in duplicate sample 508CB00601. This is below the RBC of 78,000 μg/kg. One organophosphorous pesticide, phorate, was detected at 3.7 μg/kg in sample 511CB00502 which is below its SSL (48 μg/kg).

Dioxins were detected in both samples submitted for analysis, 508CB00601 and 511CB00502, with TEQs of 2.497 ng/kg and 0.076 ng/kg, respectively. The TEQs were below the RBC for TCDD of 1,000 ng/kg.

Inorganic Analytes in Soil

Table 10.3.4 summarizes the inorganic analytical results for AOCs 508 and 511. Eight analytes were detected above their reference concentrations in soil samples: antimony, barium, beryllium, cadmium, lead, mercury, tin, and zinc. Each was above the reference concentration in upper interval samples, but barium and mercury were the only exceedances in the lower interval. Cyanide was not detected in the any of the soil samples collected at AOC 508 and AOC 511.

Hexavalent chromium was not detected in the duplicate soil samples collected at AOC 508 and AOC 511.

10.3.3 Groundwater Sampling and Analysis

Two temporary monitoring wells were installed to sample the groundwater at AOCs 508 and 511 (Figure 10.3.1). Groundwater samples were collected at this site because subsurface soils samples exceeded generic SSLs. Groundwater was sampled in accordance with the *Final Zone C Work Plan* (E/A&H, February 1995) and Section 3 of this report. Groundwater samples were analyzed for pesticides/PCBs only at DQO Level III. Table 10.3.5 summarizes the groundwater sampling and analysis.

Table 10.3.5
Groundwater Sampling and Analysis
AOC 508 — Former Incinerator/AOC 511 — Oil Storage House

Interval	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
Shallow	0	2	Pesticides/PCBs	Pesticides/PCBs	Added

Nature and Extent of Groundwater Contamination

No pesticides or PCBs were detected in groundwater sampled from AOCs 508 and 511. Therefore, it appears the concentrations present in subsurface soil are sufficiently low to be protective of groundwater. No further investigation is proposed with respect to groundwater for this site.

10.3.4 Fate and Transport Assessment

AOC 508 is the former site of an incinerator and AOC 511 is a former oil storehouse. Currently, these AOCs are grassy areas adjacent to Building 762. For the purposes of the fate and transport assessment, AOCs 508 and 511 were combined based on their proximity. Migration pathways investigated for AOCs 508 and 511 include soil to groundwater and surface soil to air. Environmental media sampled as part of the AOCs 508 and 511 RFI include surface soil and subsurface soil.

10.3.4.1 Soil-to-Groundwater Cross-Media Transport

Table 10.3.6 compares constituents found in both surface soil and subsurface soil to groundwater protection risk-based SSLs and background reference concentrations. Seven constituents

Table 10.3.6
Chemicals Detected in Surface Soil and Subsurface Soil
Comparison to Groundwater Protection SSLs and Background UTLs
NAVBASE-Charleston, Zone C, AOC 508 and 511
Charleston, South Carolina

Parameter	Surface Soil Maximum Conc.	Subsurfac Soil Maximum Conc.	Ground Water Protection SSL or UTL *	Soil Units	Soil Conc. Exceeds SSL or UTL
Acenaphthylene	110	ND	11000	UG/KG	NO
Acetone	39	20	800	UG/KG	NO
Aldrin	3.3	ND	5	UG/KG	NO
Aluminum	5150	4730	10017	MG/KG	NO
Anthracene	50	ND	430000	UG/KG	NO
Antimony	0.7	ND	0.55	MG/KG	YES
Arsenic	12.8	0.45	25	MG/KG	NO
Barium	150	130	79	MG/KG	YES
Benzo(g,h,i)perylene	470	ND	98000	UG/KG	NO
Benzo(a)pyrene Equivalents					
Benzo(a)pyrene	1100	ND	4000	UG/KG	NO
Benzo(a)anthracene	910	ND	700	UG/KG	YES
Benzo(b)fluoranthene	1700	ND	4000	UG/KG	NO
Benzo(k)fluoranthene	1900	ND	4000	UG/KG	NO
Chrysene	880	ND	1000	UG/KG	NO
Dibenzo(a,h)anthracene	120	ND	11000	UG/KG	NO
Indeno(1,2,3-cd)pyrene	450	ND	35000	UG/KG	NO
Beryllium	0.22	0.08	180	MG/KG	NO
beta-BHC	6	ND	2	UG/KG	YES
delta-BHC	34	ND	2	UG/KG	YES
gamma-BHC	2.6	ND	6	UG/KG	NO
Cadmium	0.69	ND	6	MG/KG	NO
Chlordane	520	4.2	2000	UG/KG	NO
Chromium	12.8	6.2	27	MG/KG	NO
Chromium (hexavalent)	0.01	0.01	19	MG/KG	NO
Cobalt	1.8	0.38	3	MG/KG	NO
Copper	70.7	2.4	35.3	MG/KG	YES
4,4'-DDD	350	ND	700	UG/KG	NO
4,4'-DDE	1200	5	500	UG/KG	YES
4,4'-DDT	2700	7.5	1000	UG/KG	YES
Dieldrin	200	20	1	UG/KG	YES
Dioxin (TCDD TEQ)	3.87	0.075	80	PG/G	NO
Endosulfan	14.65	ND	300	UG/KG	NO
Endrin	55	ND	400	UG/KG	NO
Endrin aldehyde	1.5	ND	400	UG/KG	NO
bis(2-Ethylhexyl)phthalate	160	ND	11000	UG/KG	NO
Fluoranthene	980	ND	980000	UG/KG	NO
Heptachlor	45	ND	60	UG/KG	NO
Lead	767	25.4	345	MG/KG	YES
Manganese	73.85	10.6	94	MG/KG	NO
Mercury	0.4	11.2	3	MG/KG	YES
Methoxychlor	94	ND	62000	UG/KG	NO
1-Methylnaphthalene	100	ND	3000	UG/KG	NO
2-Methylnaphthalene	120	ND	3000	UG/KG	NO
Naphthalene	84	ND	3000	UG/KG	NO
Nickel	5.15	1.2	21	MG/KG	NO

Table 10.3.6
Chemicals Detected in Surface Soil and Subsurface Soil
Comparison to Groundwater Protection SSLs and Background UTLs
NAVBASE-Charleston, Zone C, AOC 508 and 511
Charleston, South Carolina

Parameter	Surface Soil Maximum Conc.	Subsurfac Soil Maximum Conc.	Ground Water Protection SSL or UTL *	Soil Units	Soil Conc. Exceeds SSL or UTL
Phenanthrene	245	ND	98000	UG/KG	NO
Phorate	ND	3.7	48	UG/KG	NO
Pyrene	1300	ND	140000	UG/KG	NO
Safrole	200	ND	NA	UG/KG	YES
Selenium	1.2	0.45	3	MG/KG	NO
Silver	0.09	ND	NA	MG/KG	YES
Tin	37.1	1.4	3.3	MG/KG	YES
Toluene	8	ND	5000	UG/KG	NO
Total Petroleum Hydrocarbon	746	37.2	NA	MG/KG	YES
Vanadium	10.9	5.6	24	MG/KG	NO
Zinc	251	45.3	4200	MG/KG	NO

* - See Table 6-2
NA - Not available
ND - Not detected
SSL - Groundwater protection soil screening level
UTL - Grid-based background upper tolerance limit
MG/KG - Milligram per kilogram
UG/KG - Micrograms per kilogram

(beta-BHC, delta-BHC, copper, dieldrin, lead, mercury, and tin) were detected in AOCs 508 and 511 soil at concentrations above groundwater protection SSLs or background reference concentrations. Safrole, silver, and TPH were detected in surface soil, but could not be quantitatively evaluated in the absence of groundwater protection SSLs. Of the seven constituents listed above, only dieldrin and mercury were detected in subsurface soil above their groundwater protection SSLs. Dieldrin was found above its SSL in a single subsurface sample (511SB00202). Subsurface soil results were not available at these locations where beta and delta-BHC exceeded screening levels. This indicates a potential for an isolated impact to the shallow aquifer based on soil concentrations of dieldrin. Due to the isolated potential threat to the shallow water-bearing zone, a decision was made to conduct a limited groundwater investigation. These activities focused on chlorinated pesticides and petroleum products associated with a suspected UST. Supplemental groundwater sampling and analysis performed in August 1997 focusing on the identified source areas did not detect any chlorinated pesticide compounds. As a result, it may be concluded that reported soil levels are protective of shallow groundwater. Again, TPH is detected in the subsurface soil but cannot be quantitatively evaluated based on the absence of a groundwater protection SSL. TPH concentrations did, however, generally decrease by more than one order of magnitude in the subsurface soil. Due to the shallow water table, few subsurface soil samples were collected. The maximum copper result (70.7 mg/kg; 511SB001-01) was underlain by unimpacted soil, indicating no significant groundwater threat. SSLs exceedances for mercury and tin were isolated to single samples (511SB006-02 and 508SB006-1, respectively). Based on sample density around these locations, their respective source areas were estimated at less than 1,000 square feet. As such, neither is considered a substantial threat to shallow groundwater. Lead was detected in excess of background reference concentrations. As with other metals, lead impacts were not uniform. At AOC 508 the reference concentration was exceeded at only one location (508SB006-01). Three exceedances were reported at AOC 511: locations 511SB001-01 (607 mg/kg), 511SB008-01 (391 mg/kg), and 511SB010-01 (481 mg/kg). Where subsurface soil data were available for these AOCs, concentrations were at least an order of magnitude lower than those in surface soil. These results indicate a surface deposition with limited leaching. As a result, lead levels are not expected to represent a groundwater threat. SPLP analysis of surface soil sample 511SB006-01 produced an arsenic leachate concentration above the tap water RBC. These findings suggest a potential for impacts to the shallow groundwater from soil concentrations of arsenic, but arsenic was not detected onsite in excess of its SSL or reference concentration.

10.3.4.2 Soil-to-Air Cross-Media Transport

Table 10.3.7 lists the volatile organic compounds detected in surface soil samples collected at AOCs 508 and 511, along with corresponding soil-to-air volatilization screening levels. The maximum surface soil concentration of VOCs did not exceed its corresponding soil-to-air volatilization screening level. As a result, the soil-to-air migration pathway would not be expected to be significant at the site.

10.3.4.3 Fate and Transport Summary

Table 10.3.8 summarizes the significant constituents and migration pathways for AOCs 508 and 511.

10.3.5 Human Health Risk Assessment for AOCs 508 and 511

10.3.5.1 Site Background and Investigative Approach

This site was investigated to assess soil possibly affected by past site activities. It consists of AOCs 508 and 511, which were combined because of their proximity to one another as well as suspected similar CPSSs. Incinerator 19 (AOC 508) was operated from 1922 to 1929, and its dimensions and operating practices are unknown. AOC 508 is currently a grassy area west of Avenue H and north of AOC 511. AOC 511 is the area where Building 16 was demolished. Building 16 was used for oil storage from 1922 until approximately 1955. The design features and operating practices of this facility are unknown. Currently, the site is a grassy area west of Avenue H and north of Building 762.

Table 10.3.7
Soil-to-Air Volatilization Screening Analysis
NAVBASE - Charleston Zone C, AOC 508 and 511
Charleston, South Carolina

VOCs	Maximum Concentratio in Surface Soil	Soil to Air SSL *	Units	Exceeds SSL
Acetone	0.039	100000	MG/KG	NO
Toluene	0.008	650	MG/KG	NO

* - Soil-to-air RBCs were obtained from USEPA Soil Screening Guidance: Technical Background Document, May 1996

˙˙ ˙ble 10.3.8
ˏnificant Migration Pathways
NAVBASE-Charleston, Zone C, AOC 508 and AO
Charleston, South Carolina

	Soil to Groundwater
Dieldrin (a)	X
beta-BHC (a)	X
beta-BHC (a)	X

Notes:
(a) indicates shallow groundwater investigation found no evidence of impacts

Nine soil samples collected from the upper interval of AOC 508 and 10 from 511 were used to develop the list of methods in Table 10.3.9.

10.3.5.2 COPC Identification

Soil

Screening comparisons described in Section 7 are shown in Table 10.3.10. BEQs, lead, chlordane, DDD, DDE, DDT, and dieldrin were identified as surface soil COPCs. Although the maximum concentrations reported for DDD and DDE do not exceed the corresponding screening values, the maximum concentration reported for DDT does exceed the DDT screening value. Because DDD and DDE have toxicological properties similar to DDT and were reported onsite, they were included as COPCs. TPH concentrations exceeded 100 mg/kg in six of 12 samples (508S003, 508S006, 511S001, 511S002, 511S004, and 511S005).

Two beryllium concentrations slightly exceeded the RBC. The accuracy of the analytical method used is the detection limit, plus or minus 0.08, and the mean beryllium concentration (detections only) is 0.128. The mean beryllium concentration is less than the RBC, and the two highest concentrations were reported within the range of background concentrations. Because the mean beryllium concentration does not exceed the range of beryllium in background (based on the accuracy of the analytical method), beryllium was not considered a COPC. No COPCs were added to this HHRA based on the Wilcoxon rank sum test; the results are included in Section 5.

Groundwater

Based upon the outcome of the fate and transport assessment, a decision was made to conduct a limited groundwater investigation. These activities focused on chlorinated pesticides which were assumed to pose the greatest leaching threat, and petroleum products associated with a suspected UST. The August 1997 sampling effort did not identify chlorinated pesticide groundwater impacts in the suspected source area. As a result, no groundwater COPCs were identified.

Table 10.3.9
Methods Run at AOC 508
Surface Soil

Site	Location	Metal	SVOA	VOA	Cn	Hexa	Diox	Oppe	Herb	Pest	Tph	Otin	Eng
508	B001	Y	Y	Y	Y					Y	IR		
508	B002	Y	Y	Y	Y					Y	IR		
508	B003	Y	Y	Y	Y					Y	IR		Y
508	B004	Y	Y	Y	Y					Y	IR		
508	B005	Y	Y	Y	Y					Y	IR		
508	B006	D	D	D	D	Y	Y	Y	Y	D	IR		
508	B007	Y	Y							Y			
508	B008	Y	Y							Y			
508	B009	Y	Y							Y			
511	B001	Y	Y	Y	Y					Y	IR		
511	B002	Y	Y	Y	Y					Y	IR		
511	B003	Y	Y	Y	Y					Y	IR		
511	B004	Y	Y	Y	Y					Y	IR		
511	B005	Y	Y	Y	Y		Y			Y	IR		
511	B006	Y	Y	Y	Y					Y	IR		Y
511	B007	Y											
511	B008	Y											
511	B009	Y											
511	B010	Y											

METHODS:

Metal: TAL (Target Analyte List) Metals plus tin: Methods: 6000/7000 Series
VOA: Volatile Organic Analysis: Method 8240
SVOA: Semi-volatile Organic Analysis: Method 8270
Cn: Cyanide (Soil: Method 9010, Water: Method 9012)
Hexa: Hexavalent Chromium: Method 7195
Diox: Dioxins
Oppe: Organophosphate Pesticides: Method 8140
Herb: Chlorinated Herbicides: Method 8150
Pest: Chlorinated Pesticides: Method 8080
Tph: Total Petroleum Hydrocarbons
Otin: Organotin
Eng: Engineering Parameters

KEY:

Y: Analyzed for standard list
D: Duplicate Analysis
IR: Method 4181
DR: Extraction Method 3550, GC Method 8100
GR: Extraction Method 5030, GC Method 8015
Blank value indicates this method of analysis was not performed

Table 10.3.10
Summary of Chemicals Present in Site Samples, AOC 508 and AOC 511
Surface Soil
NAVBASE - Charleston, Zone C
Charleston, South Carolina

NAME	CONC UNITS	FREQ	DETECTS Min	DETECTS Max	DETECTS Avg	SCREENING Value	SCREENING # Over	SCREENING Source	NON-DETECTS Min	NON-DETECTS Max	BACKGROUND Value	BACKGROUND # Over
Carcinogenic PAHs												
B(a)P Equiv.	UG/KG	10 / 15	0.043	1545.88	346.6	88	5		1309.85	1403.29		
Benzo(a)anthracene	UG/KG	8 / 15	41	910	279.6	880	1	C	670	720		
Benzo(b)fluoranthene	UG/KG	9 / 15	69	1700	463.8	880	2	C	790	840		
Chrysene	UG/KG	10 / 15	39	880	253.4	88000		C	550	590		
Dibenz(a,h)anthracene	UG/KG	2 / 15	90.5	120	105.3	88	2	C	440	470		
Indeno(1,2,3-cd)pyrene	UG/KG	4 / 15	37	450	234.3	880		C	470	500		
Benzo(k)fluoranthene	UG/KG	9 / 15	38	1900	447.0	8800		C	630	670		
Benzo(a)pyrene	UG/KG	8 / 15	45	1100	309.8	88	4	C	670	720		
Dioxins												
Dioxin Equiv.	NG/KG	2 / 2	0.0755	2.4966	1.29	1000						
1234678-HpCDD	NG/KG	2 / 2	3.175	68.565	35.87							
1234678-HpCDF	NG/KG	2 / 2	1.734	37.208	19.47							
123678-HxCDD	NG/KG	1 / 2	1.93	1.93	1.93				0.372	0.372		
123478-HxCDF	NG/KG	1 / 2	5.446	5.446	5.45				0.338	0.338		
234678-HxCDF	NG/KG	1 / 2	1.065	1.065	1.07				0.343	0.343		
OCDD	NG/KG	2 / 2	22.32	511.864	267.09							
OCDF	NG/KG	2 / 2	4.112	59.578	31.85							
12378-PeCDF	NG/KG	1 / 2	0.466	0.466	0.47				0.253	0.253		
Petroleum Hydrocarbons												
Petroleum Hydrocarbons, TPH	UG/KG	12 / 12	16.5	746	209.66	100						
Inorganics												
Aluminum (Al)	MG/KG	19 / 19	2240	5150	4040.79	7800		N			9990.00	
Antimony (Sb)	MG/KG	10 / 19	0.2	0.7	0.38	3.1		N	0.2	0.26	0.55	2
Arsenic (As)	MG/KG	11 / 19	1.1	4.3	2.39	0.43	11	C	0.49	2.3	14.20	
Barium (Ba)	MG/KG	19 / 19	6.4	122	33.65	550		N			77.20	1
Beryllium (Be)	MG/KG	10 / 19	0.08	0.22	0.13	0.15	2	C	0.08	0.2		
Cadmium (Cd)	MG/KG	8 / 19	0.1	0.69	0.42	3.9		N	0.03	0.26	0.65	1
Calcium (Ca)	MG/KG	19 / 19	408	7035	1464.16	NA						

Table 10.3.10
Summary of Chemicals Present in Site Samples, AOC 508 and AOC 511
Surface Soil
NAVBASE - Charleston, Zone C
Charleston, South Carolina

	CONC		DETECTS			SCREENING			NON-DETECTS		BACKGROUND	
NAME	**UNITS**	**FREQ**	**Min**	**Max**	**Avg**	**Value**	**# Over**	**Source**	**Min**	**Max**	**Value**	**# Over**
Chromium (Cr)	MG/KG	19 / 19	3.6	12.85	6.98	39		N			26.40	
Cobalt (Co)	MG/KG	19 / 19	0.21	1.8	0.60	470		N			3.22	
Copper (Cu)	MG/KG	19 / 19	2.8	70.7	15.66	310		N			34.70	2
Iron (Fe)	MG/KG	19 / 19	1460	11700	3334.74	NA		N				
Lead (Pb)	MG/KG	19 / 19	13.8	767.5	203.44	400	3	j			330.00	4
Magnesium (Mg)	MG/KG	19 / 19	112	665.5	259.39	NA						
Manganese (Mn)	MG/KG	19 / 19	8.2	73.85	30.71	180		N			92.50	
Mercury (Hg)	MG/KG	11 / 19	0.1	0.4	0.23	2.3		N	0.11	0.11	0.24	5
Nickel (Ni)	MG/KG	19 / 19	0.85	5.15	2.32	160		N			12.30	
Potassium (K)	MG/KG	18 / 19	61.7	206	110.87	NA			52.9	52.9		
Selenium (Se)	MG/KG	7 / 19	0.49	1.2	0.75	39		N	0.46	0.48	1.44	
Silver (Ag)	MG/KG	1 / 19	0.09	0.09	0.09	39		N	0.05	0.07		
Tin (Sn)	MG/KG	19 / 19	1.2	37.1	4.27	4700					2.95	7
Vanadium (V)	MG/KG	19 / 19	3	10.9	6.62	55		N			23.40	
Zinc (Zn)	MG/KG	19 / 19	19.8	251	96.05	2300		N			159.00	4
Chlorinated Pesticides												
Aldrin	UG/KG	2 / 15	1	3.3	2.15	38		C	0.53	12		
beta-BHC	UG/KG	4 / 15	1.7	6	2.90	350		C	0.53	12		
delta-BHC	UG/KG	4 / 15	3.2	34	13.63	100		I	0.53	12		
gamma-BHC (Lindane)	UG/KG	1 / 15	2.6	2.6	2.60	490		C	0.53	12		
Chlordane	UG/KG	11 / 15	11	520	131.91	490	1	C	4.2	4.8		
4,4'-DDD	UG/KG	12 / 15	1.8	350	51.22	2700		C	3.7	3.7		
4,4'-DDE	UG/KG	13 / 15	11	1200	258.62	1900		C	3.7	19		
4,4'-DDT	UG/KG	14 / 15	17	2700	362.07	1900	1	C	3.7	3.7		
Dieldrin	UG/KG	12 / 15	0.72	200	24.28	40	1	C	1.6	8.2		
Endosulfan I	UG/KG	5 / 15	0.98	6.7	3.42	47000		N	0.8	17		
Endosulfan II	UG/KG	5 / 15	4.4	11	6.93	47000		N	1.9	40		
Endosulfan sulfate	UG/KG	3 / 15	2.6	6.55	4.62	47000		N	0.53	24		
Endrin	UG/KG	7 / 15	0.24	55	18.02	2300		N	2.5	18		
Endrin aldehyde	UG/KG	6 / 15	0.54	3.4	1.69	2300		h	0.53	12		
Heptachlor	UG/KG	1 / 15	1.7	1.7	1.70	140		C	0.53	12		

Table 10.3.10
Summary of Chemicals Present in Site Samples, AOC 508 and AOC 511
Surface Soil
NAVBASE - Charleston, Zone C
Charleston, South Carolina

NAME	CONC UNITS	FREQ	DETECTS Min	DETECTS Max	DETECTS Avg	SCREENING Value	SCREENING # Over	SCREENING Source	NON-DETECTS Min	NON-DETECTS Max	BACKGROUND Value	BACKGROUND # Over
Heptachlor epoxide	UG/KG	13 / 15	0.24	45	10.58	70		C	1.1	12		
Methoxychlor	UG/KG	9 / 15	1.1	94	24.77	39000		N	3.7	19		
2,4,5-T	UG/KG	1 / 1	12	12	12.00	78000		N				
Semivolatile Organics												
Acenaphthylene	UG/KG	3 / 15	53	110	88.17	310000		e	680	730		
Anthracene	UG/KG	2 / 15	43	50	46.50	2300000		N	760	850		
Benzo(g,h,i)perylene	UG/KG	4 / 15	41	470	252.75	310000		f	630	680		
bis(2-Ethylhexyl)phthalate (BEHP)	UG/KG	6 / 15	72	160	102.00	46000		C	790	870		
Fluoranthene	UG/KG	11 / 15	36	980	272.91	310000		N	950	1000		
1-Methyl naphthalene	UG/KG	1 / 15	100	100	100.00	310000		e	1100	1300		
2-Methylnaphthalene	UG/KG	1 / 15	120	120	120.00	310000		e	860	1000		
Naphthalene	UG/KG	1 / 15	84	84	84.00	310000		N	670	790		
Phenanthrene	UG/KG	5 / 15	41	245	112.60	310000		f	630	680		
Pyrene	UG/KG	10 / 15	39	1300	308.60	230000		N	760	790		
Safrole	UG/KG	1 / 15	200	200	200.00				590	700		
Volatile Organics												
Acetone	UG/KG	1 / 12	39	39	39.00	780000		N	22	110		
Toluene	UG/KG	5 / 12	1	8	3.60	1600000		N	16	17		

Notes:
- * Retained as a chemical of potential concern
- C The RBC is based on carcinogenic effects
- N The RBC is based on noncarcinogenic effects
- j Screening level is set equal to the soil action level
- l The RBC for gamma-BHC is used as a surrogate
- h The RBC for endrin is used as a surrogate
- e The RBC for acenaphthalene is used as a surrogate
- f The RBC for fluoranthene is used as a surrogate

10.3.5.3 Exposure Assessment

Exposure Setting

AOCs 508 and 511 occupy approximately 80,000 square feet of grassy area near Building 762, which is north of AOC 511. Current exposure would be limited to NAVBASE maintenance activities. The future use of AOCs 508 and 511 is unknown, although the site is scheduled to be a community support area in the base reuse plan.

Potentially Exposed Populations

Potentially exposed populations are current and future site workers. Additional potentially exposed populations are future site residents. Future site resident and worker exposure scenarios were addressed in this risk assessment. The hypothetical future site worker scenario assumed continuous exposure to surface soil conditions. Current site workers' exposure would be less than that assumed for the hypothetical future site worker scenario because of their limited soil contact. Therefore, the assessment for future site workers is considered protective of current site users.

Exposure Pathways

Exposure pathways for the site workers are dermal contact and incidental ingestion of surface soil. The exposure pathways for future residential land use are the same as those for the future site worker. In addition, the hypothetical future site worker scenario assumed continuous exposure to surface soil conditions. Uniform exposure was assumed for all sample locations. Table 10.3.11 presents the justification of exposure pathways assessed in this HHRA.

Exposure Point Concentrations

As discussed in Section 7, UCLs were calculated for datasets consisting of at least 10 samples. Table 10.3.12 presents the UCLs and EPCs for AOCs 508 and 511. FI/FC was not used to adjust exposure estimates for AOCs 508 and 511.

Table 10.3.11
Exposure Pathways Summary — AOC 508
NAVBASE — Zone C
Charleston, South Carolina

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Current Land Uses			
Current Site Users/Maintenance	Air, Inhalation of gaseous contaminants emanating from soil	No	No significant VOC concentrations were reported in surface soils, and portions of the site area are paved/covered by buildings.
	Air, Inhalation of chemicals entrained in fugitive dust	No	Portions of the site area are paved/covered by buildings, which limits fugitive dust generation.
	Shallow groundwater, Ingestion of contaminants during potable or general use	No	Shallow groundwater is not currently used as a source of potable or non-residential water at AOC 508.
	Shallow groundwater, Inhalation of volatilized shallow groundwater contaminants	No	Shallow groundwater is not currently used as a source of potable or non-residential water at AOC 508.
	Soil, Incidental ingestion	No (Qualified)	Future land use assessment is considered to be protective of current receptors.
	Soil, Dermal contact	No (Qualified)	Future land use assessment is considered to be protective of current receptors.
Future Land Uses			
Future Site Residents (Child and Adult) and Future Site Worker	Air, Inhalation of gaseous contaminants emanating from soil	No	No significant VOC concentrations were reported in surface soils, and portions of the site area are paved/covered by buildings.
	Air, Inhalation of chemicals entrained in fugitive dust	No	Portions of the site area are paved/covered by buildings, which limits fugitive dust generation.
	Shallow groundwater, Ingestion of contaminants during potable or general use	No	No groundwater sampling was performed in conjunction with the 508 investigation.
	Shallow groundwater, Inhalation of volatilized contaminants during domestic use	No	No groundwater sampling was performed in conjunction with the 508 investigation.

Table 10.3.11
Exposure Pathways Summary — AOC 508
NAVBASE — Zone C
Charleston, South Carolina

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Future Land Uses			
Future Site Residents (Child and Adult) and Future Site Worker	Soil, Incidental ingestion	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Soil, Dermal contact	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Wild game or domestic animals, Ingestion of tissue impacted by media contamination	No	Hunting/taking of game and/or raising livestock is prohibited within the Charleston, South Carolina, City Limits.
	Fruits and vegetables, Ingestion of plant tissues grown in media	No	The potential for significant exposure via this pathway is low relative to that of other exposure pathways assessed.

Table 10.3.12
Statistical Analysis of COPCs
Surface Soils at AOCs 508 and 511
Naval Base Charleston Zone C
Charleston, South Carolina

COPC	n	Natural Log Transforme mean	SD	H-stat	UCL (mg/kg)	MAX (mg/kg)	EPC (mg/kg)		TEF	Adjusted EPC (mg/kg)
Benzo(a)pyrene Equivalents	15	1.43502	4.537	9.746	100000+	1.546	1.546	MAX Hot Spot	1	1.546
Chlordane	15	3.5172	1.51577	3.642	0.465	0.52	0.46	UCL Used	NA	0.465
4,4'-DDE	15	4.40743	1.67263	3.936	1.931	1.20	1.20	MAX Used	NA	1.20
4,4'-DDT	15	4.60519	1.55648	3.716	1.577	2.70	1.577	UCL Used	NA	1.577
4,4'-DDD	15	2.35677	1.77956	4.138	0.368	0.35	0.350	MAX Used	NA	0.350
Dieldrin	15	1.31233	1.72232	4.029	0.105	0.20	0.105	UCL Used	NA	0.105
Lead	19	4.59941	1.33899	3.148	658.2	767.5	658.2	UCL Used	NA	658.2

NOTES:

mean arithmetic mean of the logtransformed data
n number of samples analyzed
SD standard deviation for a sample of data
H-stat "H" statistic from Gilbert 1987; cuboidal interpolation was used to determine the value in accordance with USEPA Supplemental Guidance to RAGS, Calculating the Concentration Term
NA not applicable
TEF toxic equivalency factor
EPC exposure point concentration
UCL 95 percentile upper confidence level mean

Quantification of Exposure

Soil

CDIs for ingestion and dermal contact with surface soil are shown in Tables 10.3.13 and 10.3.14, respectively.

10.3.5.4 Toxicity Assessment

Toxicity assessment terms and methods are discussed in Section 7 of this report. Each COPC identified at AOCs 508 and 511 is discussed briefly below. Table 10.3.15 presents the toxicological information used to quantify risk and hazard associated with soil COPCs.

Polyaromatic Hydrocarbons or BaP equivalents include the following list of COPCs:

Benzo(a)anthracene	TEF	0.1
Benzo(b)fluoranthene	TEF	0.1
Dibenz(a,h)anthracene	TEF	1.0
Benzo(k)fluoranthene	TEF	0.01
Benzo(a)pyrene	TEF	1.0
Indeno(1,2,3-cd)pyrene	TEF	0.1
Chrysene	TEF	0.001

Some PAHs are toxic to the liver, kidney, and blood. However, the toxic effects of the PAHs above have not been well established. There are no RfDs for the PAHs above due to a lack of data. All PAHs listed above are classified by USEPA as B2 carcinogens, and their carcinogenicity is addressed relative to that of BaP, having an oral SF 7.3 $(mg/kg\text{-}day)^{-1}$. TEFs, also set by USEPA, are multipliers that are applied to the detected concentrations, which are subsequently used to calculate excess cancer risk. These multipliers are discussed further in the exposure and toxicity assessment sections. Most carcinogenic PAHs have been classified as such due to animal

Table 10.3.13
Chronic Daily Intakes (CDI)
Incidental Ingestion of Surface Soil (0-1')
AOCs 508 and 511 Zone C
Naval Base Charleston
Charleston, SC

Chemical	TEF	Fraction Ingested fro Contaminate Source *	Exposure Point Concentration (mg/kg)	Potential Future Resident adult H-CDI (mg/kg-day)	Potential Future Resident child H-CDI (mg/kg-day)	Potential Futur Resident lwa C-CDI (mg/kg-day)	Potential Curren Worker adult H-CDI (mg/kg-day)	Potential Current Worker adult C-CDI (mg/kg-day)
Benzo(a)pyrene Equivalents	1	1	1.546	2.12E-06	1.98E-05	2.42E-06	7.56E-07	2.70E-07
Chlordane	NA	1	0.465	6.36E-07	5.94E-06	7.27E-07	2.27E-07	8.12E-08
4,4'-DDE	NA	1	1.200	1.64E-06	1.53E-05	1.88E-06	5.87E-07	2.10E-07
4,4'-DDT	NA	1	1.577	2.16E-06	2.02E-05	2.47E-06	7.71E-07	2.76E-07
4,4'-DDD	NA	1	0.350	4.79E-07	4.47E-06	5.48E-07	1.71E-07	6.12E-08
Dieldrin	NA	1	0.105	1.43E-07	1.34E-06	1.64E-07	5.12E-08	1.83E-08
Lead	NA	1	658.2	9.02E-04	8.42E-03	1.03E-03	3.22E-04	1.15E-04

NOTES:

TEF toxic equivalency factor relative to Benzo(a)pyrene
lwa lifetime weighted average; used to calculate carcinogenic CDI, RAGS Parts A and B
CDI Chronic Daily Intake in mg/kg-day
H-CDI CDI for hazard quotient
C-CDI CDI for excess cancer risk
* Reflects the estimated fraction of the site impacted by the corresponding COPC.

Table 10.3.14
Chronic Daily Intakes (CDI)
Dermal Contact with Surface Soil (0-1')
AOCs 508 and 511 Zone C
Naval Base Charleston
Charleston, SC

Chemical	TEF	Adjusted Exposure Point Concentration (mg/kg)	Fraction Contacted fro Contaminated Source *	Dermal Absorption Factor (unitless)	Potential Future Resident adult H-CDI (mg/kg-day)	Potential Future Resident child H-CDI (mg/kg-day)	Potential Futur Resident lwa C-CDI (mg/kg-day)	Potential Curren Worker adult H-CDI (mg/kg-day)	Potential Current Worker adult C-CDI (mg/kg-day)
Benzo(a)pyrene Equival	1	1.546	1	0.01	8.68E-07	2.87E-06	5.43E-07	6.20E-07	2.21E-07
Chlordane	NA	0.465	1	0.01	2.61E-07	8.61E-07	1.63E-07	1.86E-07	6.66E-08
4,4'-DDE	NA	1.200	1	0.01	6.74E-07	2.22E-06	4.22E-07	4.81E-07	1.72E-07
4,4'-DDT	NA	1.577	1	0.01	8.86E-07	2.92E-06	5.54E-07	6.33E-07	2.26E-07
4,4'-DDD	NA	0.350	1	0.01	1.97E-07	6.49E-07	1.23E-07	1.40E-07	5.01E-08
Dieldrin	NA	0.105	1	0.01	5.87E-08	1.94E-07	3.68E-08	4.20E-08	1.50E-08
Lead	NA	658.2	1	0.001	3.70E-05	1.22E-04	2.31E-05	2.64E-05	9.43E-06

NOTES:

TEF Toxic Equivalency Factor relative to Benzo(a)pyrene
CDI Chronic Daily Intake in mg/kg-day
H-CDI CDI for hazard quotient
C-CDI CDI for excess cancer risk
- The dermal absorption factor was applied to the exposure point concentration to reflect the different trans-dermal migration of inorganic versus organic chemicals
* Reflects the estimated fraction of the site impacted by the corresponding COPC.

Table 10.3.15
Toxicological Database Informatio
for Chemicals of Potential Concer
AOCs 508 and 511
NAVBASE Charleston, Zone C

Non-Carcinogenic Toxicity Data

Chemical	Oral Reference Dose (mg/kg/day)		Confidence Level	Critical Effect	Uncertainty Factor Oral	Inhalation Reference Dose (mg/kg/day)	Confidence Level	Critical Effect	Uncertainty Factor Inhalation
Benzo(a)pyrene Equivalents	ND				ND	ND			ND
Chlordane	6E-05	a	L	liver hypertrophy		ND			ND
4,4'-DDD	ND				ND	ND			ND
4,4'-DDE	ND				ND	ND			ND
4,4'-DDT	0.0005	a	M	liver lesions	100	ND			ND
Dieldrin	5E-05	a	M	liver lesions	100	ND			ND
Lead	ND				ND	ND			ND

NOTES:

a Integrated Risk Information System (IRIS)
b Health Effects Assessment Summary Tables (HEAST)
c HEAST alternative method
d USEPA Region III Screening Tables
e EPA Environmental Criteria and Assessment Office - Cincinnati (provisional)
f Withdrawn from IRIS or HEAST
Toxicological data for naphthalene were used as surrogates for 2-methylnaphthalene.
NA Not applicable or not available
ND Not determined due to lack of information

Table 10.3.15
Toxicological Database Informatio
for Chemicals of Potential Concer
AOCs 508 and 511
NAVBASE Charleston, Zone C

Carcinogenic Toxicity Data

Chemical	Oral Slope Factor [(mg/kg/day)]-1		Inhalation Slope Factor [(mg/kg/day)]-1		Weight of Evidence	Tumor Type
Benzo(a)pyrene Equivalents	7.3	a			B2	mutagen
Chlordane	1.3	a	ND		B2	liver carcinoma
4,4'-DDD	0.024	a	ND		B2	liver
4,4'-DDE	0.34	a	ND		B2	liver
4,4'-DDT	0.34	a	ND		B2	liver
Dieldrin	16	a	16.1	a	B2	hepatoma
Lead	ND		ND		B2	various

studies using large doses of purified PAHs. There is some doubt as to the validity of these listings, and the SFs listed in USEPA's RBC table are provisional. However, these PAHs are carcinogens when the exposure involves a mixture of other carcinogenic substances (e.g., coal tar, soot, cigarette smoke, etc.). As listed in IRIS (search data June 28, 1995), the basis for the BaP B2 classification is a lack of human data specifically linking BaP to a carcinogenic effect. However, multiple animal studies in many species demonstrating BaP to be carcinogenic by numerous routes.

BaP has produced positive results in numerous genotoxicity assays. At the June 1992 CRAVE Work Group meeting, a revised risk estimate for BaP was verified. This section provides information on three aspects of the carcinogenic risk assessment for the agent in question: the USEPA classification and quantitative estimates of exposure. The classification reflects a weight-of-evidence judgment of the likelihood that the agent is a human carcinogen. The quantitative risk estimates are presented in application of a low-dose extrapolation procedure and presented as the risk per mg/kg-day. The unit risk is the quantitative estimate in terms of either risk per μg/L drinking water or risk per μg/m^3 air breathed. The third form in which risk is presented is drinking water or air concentration providing cancer risks of one in 10,000 or one in 1,000,000. The Carcinogenicity Background Document provides details on the carcinogenicity values found in IRIS. Users are referred to the oral reference dose and reference concentration sections for information on long-term toxic effects other than carcinogenicity.

As listed in IRIS (search date June 28, 1995), the basis for the dibenz(a,h)anthracene and benzo(b)fluoranthene B2 classification is no human data but sufficient data from animal bioassays. Benzo(b)fluoranthene produced tumors in mice after lung implantation, intraperitoneal or subcutaneous injection, and skin painting. As listed in IRIS (search date June 28, 1995), the basis for the benzo(a)anthracene B2 classification is no human data but sufficient data from animal bioassays. Benzo(a)anthracene produced tumors in mice exposed by gavage; intraperitoneal, subcutaneous, or intramuscular injection; and topical application. Benzo(a)anthracene produced mutations in bacteria and in mammalian cells, and transformed mammalian cells in culture. As listed in IRIS (search date June 28, 1995) the basis for the benzo(k)fluoranthene B2 classification is no human data but sufficient data from animal bioassays. Benzo(k)fluoranthene produced tumors after lung implantation in mice and when administered with a promoting agent in skin-painting studies. Equivocal results have been found in a lung adenoma assay in mice. Benzo(k)fluoranthene is mutagenic in bacteria (Klaassen, et al., 1986).

Other PAHs — those not classified by USEPA as carcinogens — are toxic to the liver, kidney and blood. This group of PAHs includes compounds such as pyrene, acenaphthene, acenaphthylene, benzo(g,h,i)perylene, and phenanthrene. USEPA determined RfDs for only two of these compounds: pyrene's RfDo of 0.03 mg/kg-day is also used as a surrogate RfDo for phenanthrene. The RfDo for acenaphthene was 0.06 mg/kg-day.

Lead has been classified as a group B2 carcinogen by USEPA based on animal data. No RfD or SF has been set by USEPA. However, an action level for soil protective of child residents has been proposed by USEPA Region IV, 400 mg/kg. USEPA's OSWER has recommended a 1,000 mg/kg cleanup standard for industrial properties. USEPA's Office of Water has established a treatment technique action level of 15 μg/L. As listed in IRIS (search date October 17, 1995), the classification is based on sufficient animal evidence. Ten rat bioassays and one mouse assay have shown statistically significant increases in renal tumors with dietary and subcutaneous exposure to several soluble lead salts. Animal assays provide reproducible results in several laboratories, in multiple rat strains with some evidence of multiple tumor sites. Shortterm studies show that lead affects gene expression. Human evidence is inadequate. An RfD and an SF have not been set because of the confounding nature of lead toxicity. Lead can accumulate in bone marrow, and effects have been observed in the CNS, blood, and mental development of children. RfDs are based on the assumption that a threshold must be exceeded to result in toxic effects (other than carcinogenicity). Once lead accumulates in the body, other influences cause the actual levels in the blood to fluctuate — sometimes the lead is attached to binding sites; sometimes lead is free-flowing. If an exposed individual has previously been exposed to lead, this individual could lose weight and set fat-bound lead free. This fluctuation and lack of previous lead exposure data are two of the reasons lead effects are difficult to predict (Klaassen, et al., 1986). The USEPA has developed the Lead Uptake/Biokinetic Model (Version 0.99d) (Lead Model) to assist in determining the probability that children (0 to 7 years of age) would suffer adverse effects as a result of exposure to environmental media impacted by lead. The model was applied to assess the threat to a child receptor posed by elevated surface soil lead concentrations reported at AOC 670. The Lead Model applications are discussed in Section 6.2.4.5.

Chlordane is a polycyclic chlorinated pesticide. Acute exposure to high doses of chlordane causes tremors and convulsions. Chronic exposure can cause emotional and neuromuscular disturbances. Exposed individuals revert to normal approximately one week after the source is removed (Dreisbach et al., 1987). USEPA has established an oral RfD of 6E-5 mg/kg-day and an oral SF of 1.3 $(mg/kg\text{-}day)^{-1}$.

Dieldrin is a polycyclic chlorinated pesticide. Short-term exposure to high doses of dieldrin causes tremors and convulsions. Chronic exposure can cause emotional and neuromuscular disturbances. Exposed individuals revert to normal approximately one week after the dieldrin source is removed. As listed in IRIS (search date June 28, 1995), the basis for the B2 classification is that dieldrin is carcinogenic in seven strains of mice when administered orally. Dieldrin is structurally related to compounds (aldrin, chlordane, heptachlor, heptachlor epoxide, and chlorendic acid) which produce tumors in rodents. Dieldrin is classified as a B2 carcinogen by USEPA; the SFo, SFi, and RfDo were set to 16 $(mg/kg\text{-}day)^{-1}$, 16.1 $(mg/kg\text{-}day)^{-1}$, and 0.00005 mg/kg-day, respectively. As listed in IRIS (search date June 28, 1995), the critical effect of this chemical is liver lesions. The uncertainty factor was determined to be 100 and the modifying factor was determined to be 1. (Dreisbach, et al., 1987).

4,4'-DDD, a by-product of the pesticide DDT, is a compound typical of halobenzene derivatives. It is soluble in fat, but not in water, and its target organ is the brain. This analog of DDT is the least toxic of the three primary DDT analogues (i.e., the least likely to cause cancer). Other DDD effects could include cell death in the liver, fatty change of heart muscles, and kidney damage. In a study mentioned in Dreisbach, et al. workers historically exposed to DDT had up to 648 ppm DDT in their body fat with no adverse health effects observed. If an individual loses body fat, DDD concentrations are not stored at sufficient concentrations to induce toxic effects. This compound is listed as a B2 carcinogen, and USEPA set the SFo for DDD to 0.24 $(mg/kg\text{-}day)^{-1}$ (Dreisbach, et al., 1987).

4,4'-DDE, a compound typical of halobenzene derivatives, is a by-product of the pesticide DDT. It is soluble in fat, but not in water, and its primary target organs are the liver and brain. DDE is the form of DDT which accumulates in organisms and is thought to be responsible for egg shell thinning and other ecological effects. DDE bioconcentrates in aquatic organisms and can significantly alter the ecology of some areas, especially where DDE-containing aquatic species are a critical species in the food chain. This compound is listed as a B2 carcinogen, and USEPA set the SFo for DDE to 0.34 $(mg/kg\text{-}day)^{-1}$ (Dreisbach, et al. 1987; Harte, et al. 1991).

4,4'-DDT is a pesticide which is soluble in fat, but not in water. The primary target organ is the brain. Other DDT effects could include cell death in the liver, fatty change of heart muscles, and kidney damage. In a study mentioned in Dreisbach, et al. workers historically exposed to DDT had up to 648 ppm DDT in their body fat with no adverse health effects observed. If an individual loses body fat, DDD concentrations are not stored at sufficient concentrations to induce toxic effects (Dreisbach, et al., 1987). DDE is the form of DDT which accumulates in organisms and is thought to be responsible for egg shell thinning and other ecological effects. DDE bioconcentrates in aquatic organisms and can significantly alter the ecology of some areas, especially where DDE-containing aquatic species are a critical species in the food chain (Dreisbach, et al., 1987; Harte, et al., 1991). As listed in IRIS (search date January 15, 1996), the critical noncarcinogenic effect of DDT is liver lesions. USEPA determined the oral RfD to be 0.0005 mg/kg-day, with an uncertainty factor of 100 and a modifying factor of 1.0. Confidence in the RfD is medium. DDT is a class B2 carcinogen based on tumors observed in seven studies in various mouse strains and three studies in rats. DDT is structurally similar to other probable carcinogens, such as DDD and DDE. USEPA determined the slope factor to be 0.34 $(mg/kg\text{-}day)^{-1}$.

10.3.5.5 Risk Characterization

Surface Soil Pathways

Exposure to surface soil onsite was evaluated under both residential and industrial (site worker) scenarios. For these scenarios, the incidental ingestion and dermal contact exposure pathways were evaluated. For noncarcinogenic contaminants evaluated for future site residents, hazard was computed separately to address child and adult exposure. Tables 10.3.16 and 10.3.17 present the estimated carcinogenic risks and/or HQs associated with the incidental ingestion of and dermal contact with site surface soil, respectively.

Hypothetical Site Residents

The ingestion ILCR (based on adult and child lifetime weighted average) for AOCs 508 and 511 surface soil is 2E-5. The dermal pathway ILCR is 1E-5. BEQs and dieldrin were the primary contributors for each pathway.

Table 10.3.16
Hazard Quotients and Incremental Lifetime Cancer Risks
Incidental Surface Soil Ingestion
AOCs 508 and 511 Zone C
Naval Base Charleston
Charleston, SC

Chemical	Oral RfD Used (mg/kg-day)	Oral SF Used (mg/kg-day)-1	Potential Future Resident adult Hazard Quotient	Potential Future Resident child Hazard Quotient	Potential Futur Resident lwa ILCR	Potential Curren Worker adult Hazard Quotient	Potential Current Worker adult ILCR
Benzo(a)pyrene Equivale	NA	7.3	ND	ND	1.8E-05	ND	2.0E-06
Chlordane	6E-05	1.3	0.011	0.10	9.5E-07	0.0038	1.1E-07
4,4'-DDE	NA	0.34	ND	ND	6.4E-07	ND	7.1E-08
4,4'-DDT	0.0005	0.34	0.004	0.04	8.4E-07	0.0015	9.4E-08
4,4'-DDD	NA	0.24	ND	ND	1.3E-07	ND	1.5E-08
Dieldrin	5E-05	16	0.003	0.03	2.6E-06	0.0010	2.9E-07
Lead	NA	NA	ND	ND	ND	ND	ND
SUM Hazard Index/ILCR			0.02	0.2	2E-05	0.01	3E-06

NOTES:

NA Not available
ND Not Determined due to lack of available information
lwa lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime excess Cancer Risk

Table 10.3.17
Hazard Quotients and Incremental Lifetime Cancer Risks
Dermal Contact With Surface Soil
AOCs 508 and 511 Zone C
Naval Base Charleston
Charleston, SC

Chemical	Dermal Adjustment	Oral RfD Used (mg/kg-day	Oral SF Used (mg/kg-day)-1	Potential Future Resident adult Hazard Quotient	Potential Future Resident child Hazard Quotient	Potential Futu Resident lwa ILCR	Potential Curren Worker adult Hazard Quotient	Potential Current Worker adult ILCR
Benzo(a)pyrene Equiv	0.5	NA	14.6	ND	ND	7.9E-06	ND	3.2E-06
Chlordane	0.5	3E-05	2.6	0.009	0.029	4.2E-07	0.0062	1.7E-07
4,4'-DDE	0.5	NA	0.68	ND	ND	2.9E-07	ND	1.2E-07
4,4'-DDT	0.5	0.00025	0.68	0.004	0.012	3.8E-07	0.0025	1.5E-07
4,4'-DDD	0.5	NA	0.48	ND	ND	5.9E-08	ND	2.4E-08
Dieldrin	0.5	2.5E-05	32	0.002	0.008	1.2E-06	0.0017	4.8E-07
Lead	0.2	NA	NA	ND	ND	ND	ND	ND
SUM Hazard Index/ILCR				0.002	0.008	1E-05	0.002	4E-06

NOTES:

NA Not available
ND Not Determined due to lack of available information
lwa lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime excess Cancer Risk
\- Dermal to absorbed dose adjustment factor is applied to adjust for Oral SF and RfD (i.e., the oral RfD is based on oral absorption efficiency which should not be applied to dermal exposure and dermal CDI)

The ingestion HIs for the adult and child residents were 0.02 and 0.2, respectively. The dermal contact HIs for the adult and child residents were 0.002 and 0.008, respectively. Chlordane was the primary contributor to the HI for both the ingestion and dermal contact exposure pathways.

Hypothetical Site Workers

Site worker ILCR was estimated to be 3E-6 and 4E-6 for the ingestion and dermal contact pathways, respectively. BEQ and dieldrin were the primary contributors for each pathway. Site worker ingestion and dermal contact HIs were 0.01 and 0.002, respectively. Chlordane was the primary contributor to the HI for both the ingestion and dermal contact exposure pathways.

Lead Toxicity

At AOCs 508 and 511, three of 19 surface soil samples contained lead at concentrations exceeding the residential cleanup goal of 400 mg/kg. The mean lead concentration at AOCs 508 and 511 was calculated to be 201.75 mg/kg. Both AOC 508 and 511 represent an area smaller than a standard one-half acre residential exposure area. The mean lead concentration at AOC 508 was computed to be 188 mg/kg and that at AOC 511 was 218 mg/kg. Because the mean lead concentration in each of these exposure areas is below the residential cleanup goal, chronic exposure is not expected to pose a significant health threat to hypothetical child residents.

COCs Identified

COCs are identified based on cumulative (all pathways) risk and hazard projected for this site. USEPA has established a generally acceptable risk range of 1E-4 to 1E-6, and a hazard index threshold of 1.0 (unity). In this HHRA, a COC was considered to be any chemical contributing to a cumulative risk level of 1E-6 or whose hazard quotient exceeds 0.1. For carcinogens, this approach is relatively conservative, because a cumulative risk level of 1E-4 (and individual ILCR of 1E-6) is recommended by USEPA Region IV as the trigger for establishing COCs. The COC selection method presented was used to provide a more comprehensive evaluation of chemicals contributing to carcinogenic risk or noncarcinogenic hazard during the RGO development process. Table 10.3.18 summarizes COCs identified as well as risk and hazard for each exposure pathway and scenario.

Surface Soil

Hypothetical Site Residents (Future Land Use)

BEQ, dieldrin, chlordane, and DDT were identified as COCs for this scenario based on the sum ILCR. BEQs and dieldrin are shown on Figures 10.3.2 and 10.3.3.

Hypothetical Site Workers (Future Land Use)

BEQs were identified as COCs for this scenario based on the sum ILCR or hazard index.

10.3.5.6 Risk Uncertainty

Characterization of Exposure Setting and Identification of Exposure Pathways

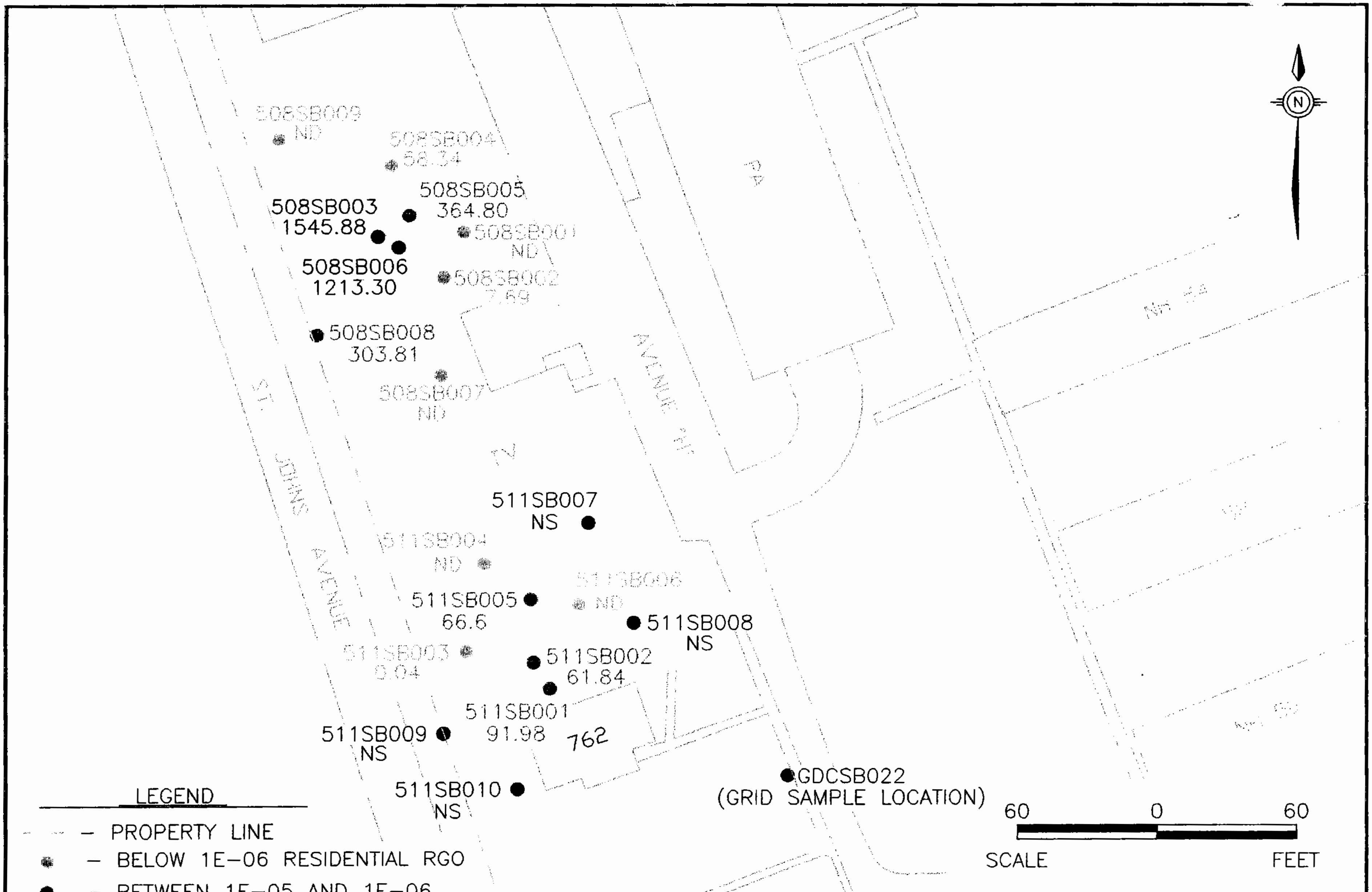
The potential for high bias is introduced through the exposure setting and pathway selection due to the highly conservative assumptions (i.e., future residential use) recommended by USEPA Region IV when assessing potential future and current exposure. The exposure assumptions made in the site worker scenario are highly protective and would tend to overestimate exposure. Under current site use conditions, workers are infrequently exposed to surface soil when performing maintenance activities or walking across the site. Most of the site is either vegetated or paved, limiting fugitive dust generation and exposure to soil.

Residential use of the site would not be expected based on current reuse plans, which have scheduled AOCs 508 and 511 to be used as a community support area. If this area is used as a residential site, the buildings would be demolished and surface soil conditions would likely change — the soil could be covered with landscaping soil and/or a house. Consequently, exposure to current surface soil conditions would not be likely under a true future residential scenario. These

Table 10.3.18
Summary of Risk and Hazard-based COCs
AOCs 508 and 511 Zone C
NAVBASE - Charleston
Charleston, South Carolina

Medium	Exposure Pathway		Potential Futu Resident Adul Hazard Quotie	Potential Futu Resident Chil Hazard Quotie	Potential Future Resident Iwa ILCR	Site Worker Hazard Quotie	Site Worker ILCR	Identification of COCs	
Surface Soil	Incidental Ingestion	Benzo(a)pyrene Equivalents	ND	ND	1.8E-05	ND	2.0E-06	2	4
		Chlordane	0.01	0.10	9.5E-07	0.004	1.1E-07	2	
		4,4'-DDE	ND	ND	6.4E-07	ND	7.1E-08		
		4,4'-DDT	0.00	0.04	8.4E-07	0.002	9.4E-08	2	
		4,4'-DDD	ND	ND	1.3E-07	ND	1.5E-08		
		Dieldrin	0.00	0.03	2.6E-06	0.001	2.9E-07	2	
		Lead	ND	ND	ND	ND	ND		
	Dermal Contact	Benzo(a)pyrene Equivalents	ND	ND	7.9E-06	ND	3.2E-06	2	4
		Chlordane	0.009	0.029	4.2E-07	0.006	1.7E-07	2	
		4,4'-DDE	ND	ND	2.9E-07	ND	1.2E-07		
		4,4'-DDT	0.004	0.012	3.8E-07	0.003	1.5E-07	2	
		4,4'-DDD	ND	ND	5.9E-08	ND	2.4E-08		
		Dieldrin	0.002	0.008	1.2E-06	0.002	4.8E-07	2	
		Lead	ND	ND	ND	ND	ND		
Surface Soil Pathway Sum			0.03	0.2	3E-05	0.015	6E-06		
Sum of All Pathways			0.03	0.2	3E-05	0.02	6E-06		

Notes:
ND indicates not determined due to the lack of available risk information.
ILCR indicates incremental excess lifetime cancer risk
HI indicates hazard index
1- Chemical is a COC by virtue of projected child residence non-carcinogenic hazard.
2- Chemical is a COC by virtue of projected future resident lifetime ILCR.
3- Chemical is a COC by virtue of projected site worker non-carcinogenic hazard.
4- Chemical is a COC by virtue of projected site worker ILCR.



ZONE C
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CHARLESTON, S.C.

FIGURE 10.3.2
AOC #508–FORMER INCINERATOR
AOC #511–FORMER OIL STORAGE HOUSE
BEQs IN SURFACE SOIL

DWG DATE: 10/22/97 | DWG NAME: 2903BEQS

LEGEND

— PROPERTY LINE

— BELOW 1E-06 RESIDENTIAL RGO

— BETWEEN 1E-05 AND 1E-06 RESIDENTIAL RGO

ALL RESULTS ARE IN μg/kg

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FIGURE 10.3.3
AOC #508–FORMER INCINERATOR
AOC #511–FORMER OIL STORAGE HOUSE
DIELDRIN IN SURFACE SOIL

DWG DATE: 10/24/97 | DWG NAME: 2903DSS3

factors indicate that exposure pathways assessed in this HHRA would generally overestimate the risk and hazard posed to site workers and future site residents.

Determination of Exposure Point Concentrations

The UCL of the concentrations reported for COPCs were used as the EPCs for surface soil.

Frequency of Detection and Spatial Distribution

BEQ was reported in 10 of 15 soil samples, and five of the reported detections exceeded the BEQ RBC. Four exceedances were at AOC 508 in samples 508S003, 508S005, 508S006, and 508S008, while one detection exceeded the BEQ RBC at 511S001. DDT was reported in 14 of 15 samples, and only one concentration exceeded the RBC. Similarly, dieldrin was reported in 12 of 15 samples, and only one detection exceeded the RBC. Of the 11 detections reported for chlordane, only two exceeded the RBC, while lead exceeded the residential action level at three of 19 sample locations.

The two primary contributors to ILCR were BEQ and dieldrin. These compounds were reported at concentrations higher than the corresponding RBC at only one sample location each. Assuming site-wide exposure to only two sample locations is highly conservative. If concentrations of these compounds were consistently elevated across the site, more confidence could be given to the exposure estimates. Because of the low frequency of elevated BEQ and dieldrin concentrations, exposure estimates for these compounds would be overestimates.

Due to limited subsurface soil data, the potential for underestimation of risk/hazard related to the soil to groundwater migration pathways was considered high. Numerous chemicals, principally chlorinated pesticides, were detected in surface soil above leachability-based screening values. To reduce the uncertainty surrounding this issue, a supplemental groundwater investigation was performed. Because no COPCs were identified in groundwater, underestimation of risk/hazard is not thought a significant concern.

Quantification of Risk/Hazard

As indicated by the discussions above, the uncertainty inherent in the risk assessment process is great. In addition, many site-specific factors affecting the uncertainty of this assessment would upwardly bias the risk and hazard estimates. Exposure pathway-specific sources of uncertainty are discussed below.

Soil

Beryllium was not considered a COPC because the mean beryllium concentration does not exceed the RBC and the highest concentrations do not exceed the range of beryllium in background (based on the accuracy of the analytical method). With better analytical technology, more certainty could be given to beryllium No COPCs were added to this HHRA based on the Wilcoxon rank sum test. Results are included in Section 5.

Because the future land use of AOCs 508 and 511 is unknown, both the worker and residential exposure scenarios were assessed in this HHRA. As previously discussed, these scenarios would likely lead to overestimates of risk and/or hazard, especially under RME assumptions. An individual map was not produced for this site.

The CT assumption for residential exposure duration is nine years compared to the 30-year assumption for RME. Exposure frequency would change from 350 to 234 days per year, and applicable ingestion rates would be reduced by one-half. These changes reduce exposure estimates to 90% of those calculated under RME assumptions.

10.3.5.7 Risk Summary

The risk and hazard posed by contaminants at AOCs 508 and 511 were assessed for the hypothetical RME site worker and the hypothetical RME future site resident. In surface soil, the incidental ingestion and dermal contact pathways were assessed in this HHRA. Table 10.3.19 summarizes the exposure pathway and exposure scenario risk and hazard estimates for AOCs 508 and 511.

10.3.5.8 Remedial Goal Options

Soil

RGOs for the hypothetical site residential and site worker scenarios were calculated for the COCs identified as shown in Tables 10.3.20 and 10.3.21, respectively. Inclusion in an RGO table does not necessarily indicate that remedial action is warranted. RGOs are options to be considered when making risk management decisions which, in accordance with RAGS, are not to be included in HHRAs.

10.3.6 Corrective Measures Considerations for AOCs 508 and 511

Based on analytical results and the risk assessment, several COCs were identified for these sites. BaP equivalents, chlordane, 4,4'-DDT, and dieldrin were identified in the surface soil (upper interval). Potential corrective measures for the chemicals of concern are listed in Table 10.3.22.

Table 10.3.19
Summary of Risk and Hazard for AOCs 508 and 511
NAVBASE - Charleston Zone C
Charleston, South Carolina

Medium	Exposure Pathway	HI (Adult)	HI (Child)	ILCR (LWA)	HI (Worker)	ILCR (Worker)
Surface Soil	Incidental Ingestion	0.02	0.2	2E-05	0.01	3E-06
	Dermal Contact	0.002	0.01	1E-05	0.002	4E-06
Sum of All Pathways		0.02	0.2	3E-05	0.01	7E-06

Notes:
ND indicates not determined due to the lack of available risk information.
ILCR indicates incremental excess lifetime cancer risk
HI indicates hazard index

Table 10.3.20
Residential-Based Remedial Goal Options Surface Soil
AOCs 508 and 511 Zone C
Naval Base Charleston
Charleston, South Carolina

Chemical	Slope Factor (mg/kg-day)-1	Reference Dose (mg/kg-day)	FI/FC Factor	Unadjusted EPC mg/kg	**Hazard-Based Remedial Goal Options** **3** mg/kg	**1** mg/kg	**0.1** mg/kg	**Risk-Based Remedial Goal Options** **1E-06** mg/kg	**1E-05** mg/kg	**1E-04** mg/kg	Background Concentration mg/kg
Benzo(a)pyrene Equivalents	7.3	NA	1	1.546	ND	ND	ND	0.06	0.6	6	NA
Chlordane	1.3	6E-05	1	0.465	ND	ND	ND	0.34	3.4	34	NA
4,4'-DDT	0.34	0.0005	1	1.577	ND	ND	ND	1.30	13.0	130	NA
Dieldrin	16	5E-05	1	0.105	ND	ND	ND	0.03	0.3	3	NA

NOTES:

EPC exposure point concentration
NA not applicable
ND not determined
- remedial goal options were based on the residential lifetime weighted average for carcinogens and the child resident for noncarcinogens

Table 10.3.21
Worker-Based Remedial Goal Options Surface Soil
AOCs 508 and 511 Zone C
Naval Base Charleston
Charleston, South Carolina

Chemical	Slope Factor (mg/kg-day)-1	Reference Dose (mg/kg-day)	FI/FC Factor	Unadjusted EPC mg/kg	Hazard-Based Remedial Goal Options 3 mg/kg	1 mg/kg	0.1 mg/kg	Risk-Based Remedial Goal Options 1E-06 mg/kg	1E-05 mg/kg	1E-04 mg/kg	Background Concentration mg/kg
Benzo(a)pyrene Equivalents	7.3	NA	1	1.546	ND	ND	ND	0.30	3.0	30	NA

NOTES:

EPC exposure point concentration
NA not applicable
ND not determined

Table 10.3.22
Potential Corrective Measures

Medium	Compounds	Potential Corrective Measures
Surface Soil	Benzo(a)pyrene	a) No action, intrinsic remediation and monitoring b) Containment/capping c) Ex-situ, physical, chemical and biological treatment d) In-situ, biological treatment
Surface Soil	Chlordane, 4,4'-DDT, and Dieldrin	a) No action, intrinsic remediation, and monitoring b) Containment/capping c) Ex-situ, physical, chemical and biological treatment d) In-situ, chemical and biological treatment

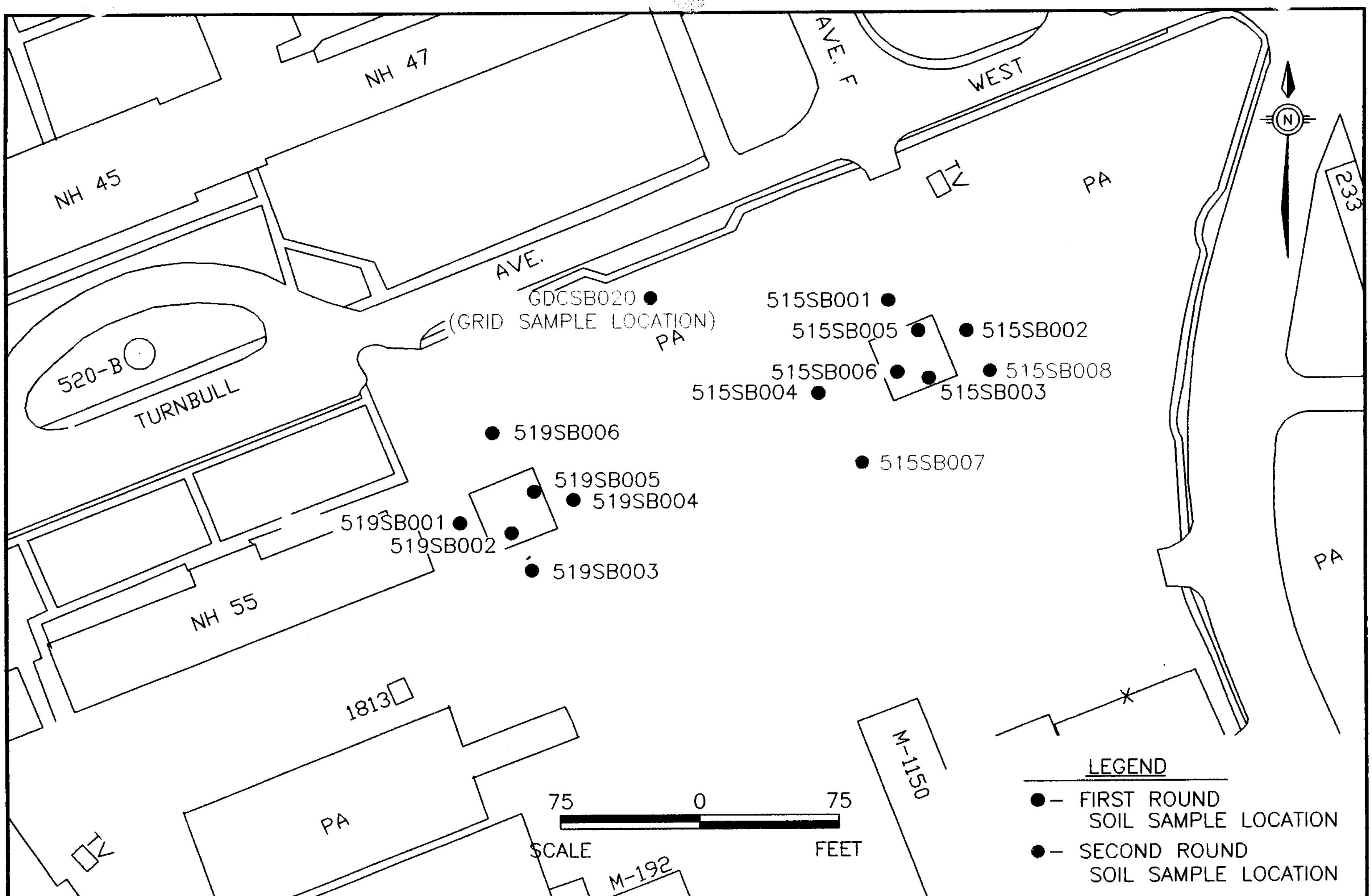
10.4 AOC 515 — Former Incinerator and AOC 519 — Former Boiler House

AOC 515 is a gravel parking area approximately 100 feet east of Building NH-55 that operated as an incinerator in the 1920s and as a paint shop in the 1930s (Figure 10.4.1). Potential contaminants include paints, solvents, residue of incomplete combustion, or petroleum hydrocarbons. AOC 519 is a gravel parking area on the east side of Building NH-55. A boiler house operated onsite from 1922 until 1929. Potential contaminants include petroleum hydrocarbons, coal, or coal derivatives (SVOCs). A CSI was performed at AOCs 515 and 519 to identify impacts to soil, if any, from former site operations.

10.4.1 Soil Sampling and Analysis

Soil was sampled in accordance with the *Final Zone C Work Plan*, (E/A&H, November 1995) and as outlined in Section 3 of this report. Sampling locations were selected following review of historical maps of the area and were placed at locations most likely impacted if a release had occurred. Figure 10.4.1 shows sample locations.

Soil was sampled in two rounds. First-round samples were collected from 12 locations (one upper and one lower interval soil sample per location). First-round soil samples were analyzed for VOCs, SVOCs, pesticides/PCBs, metals, cyanide, and TPH at DQO Level III. Two duplicate soil samples were submitted for Appendix IX analyses at DQO Level IV. This includes the parameters listed above as well as herbicides, hexavalent chromium, organophosphorous pesticides, and dioxins. Table 10.4.1 summarizes first-round soil sampling and analysis.



ZONE C
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FIGURE 10.4.1
AOC #515–FORMER INCINERATOR
AOC #519–FORMER PAINT SHOP
SOIL SAMPLE LOCATIONS

DWG DATE: 09/25/97 | DWG NAME: 29CHZC12

Table 10.4.1
First Round — Soil Sampling and Analysis
AOC 515 — Former Incinerator and AOC 519 — Former Boiler House

Interval	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
Upper	6	6	TPH, Standard Suite[a]	TPH, Standard Suite[a]	None
Lower	6	6	TPH, Standard Suite[a]	TPH, Standard Suite[a]	None

Note:
[a] = Standard Suite includes VOCs, SVOCs, metals, cyanide, and pesticide/PCBs.

A preliminary review of the first round soil data indicated the RBC for BaP was exceeded in sample 515SB00301. Two supplemental sample locations were added adjacent to this location to delineate the extent of SVOC contamination. One upper interval sample collected from each location was submitted for SVOCs analysis. Table 10.4.2 summarizes the second-round sampling and analysis.

Table 10.4.2
Second Round — Soil Sampling and Analysis
AOC 515 — Former Incinerator and AOC 519 — Former Boiler House

Interval	Samples Proposed	Samples Performed	Analyses Proposed	Analyses Performed	Deviations
Upper	NA	2	SVOCs	SVOCs	Added
Lower	NA	0	None	None	None

10.4.2 Nature and Extent of Soil Contamination

Soil analytical results for organics are in Table 10.4.3, and results for inorganics are in Table 10.4.4. Appendix D is a complete analytical report for Zone C, including AOCs 515 and 519. Appendix H contains detection only summary tables.

Table 10.4.3
Organic Compound Analytical Results for Soil
AOC 515 — Former Incinerator and AOC 519 — Former Boiler House

Compound	Sample Interval	Frequency of Detection	Range of Detection	Mean	RBC[a]	Number of Samples Exceeding RBC
Volatile Organic Compounds (µg/kg) **(Upper Interval — 12 Samples plus 1 Duplicate/Lower Interval — 12 Samples plus 1 Duplicate)**						
Methylene chloride	Upper	1/12	15.0	NA	85,000	0
Vinyl acetate	Upper	2/12	1.0 - 8.0	4.5	78,000,000	0
	Lower	1/12	11.0	NA	8,400	0
Semivolatile Organic Compounds (µg/kg) **(Upper Interval — 14 Samples plus 1 Duplicate/Lower Interval — 12 Samples plus 1 Duplicate)**						
Anthracene	Upper	1/14	55.0	NA	2,300,000	0
Benzo(a)anthracene	Upper	5/14	42.0 - 200.0	94.0	880[b]	0
Benzo(a)pyrene	Upper	2/14	39.0 - 190.0	114.5	88[b]	1
Benzo(b)fluoranthene	Upper	4/14	110.0 - 310.0	195.0	880[b]	0
Benzo(k)fluoranthene	Upper	4/14	130.0 - 440.0	242.5	8,800[b]	0
Chrysene	Upper	5/14	49.0 - 220.0	111.0	8,800[b]	0
Fluoranthene	Upper	5/14	52.0 - 450.0	172.6	310,000	0
Phenanthrene	Upper	3/14	49.0 - 290.0	140.0	230,000	0
Pyrene	Upper	5/14	50.0 - 390.0	157.6	230,000	0
BEQ	Upper	5/14	4.35 - 245.62	72.85	88	1
Pesticide and PCB Compounds (µg/kg) **(Upper Interval — 12 Samples plus 1 Duplicate/Lower Interval — 12 Samples plus 1 Duplicate)**						
Aldrin	Upper	4/12	0.110 - .50	0.273	38	0
	Lower	2/12	0.37 - 0.140	0.089	5	0
alpha-BHC	Upper	1/12	0.093	0.093	100	0
beta-BHC	Upper	4/12	0.55 -1.90	1.05	350	0
	Lower	1/12	0.320	0.320	2	0
delta-BHC	Upper	1/12	0.17	0.17	350	0
gamma-BHC	Upper	1/12	0.089	NA	490	0
4,4-DDD	Upper	8/12	0.38 -11.0	3.784	2,700	0
	Lower	5/12	0.24 - 0.40	0.289	700	0

Table 10.4.3
Organic Compound Analytical Results for Soil
AOC 515 — Former Incinerator and AOC 519 — Former Boiler House

Compound	Sample Interval	Frequency of Detection	Range of Detection	Mean	RBC[a]	Number of Samples Exceeding RBC
Pesticide and PCB Compounds (μg/kg) (Upper Interval — 12 Samples plus 1 Duplicate/Lower Interval — 12 Samples plus 1 Duplicate)						
4,4DDE	Upper	12/12	0.31 - 210.0	49.567	1,900	0
	Lower	7/12	1.10 -2.30	1.529	500	0
4,4-DDT	Upper	11/12	0.60 - 150.0	31.155	1,900	0
	Lower	6/12	0.42 - 0.96	0.695	1,000	0
Dieldrin	Upper	3/12	0.77 - 3.4	1.707	40	0
	Lower	1/12	0.840	NA	1	0
Endosulfan I	Upper	6/12	0.14 - 1.2	0.665	47,000	0
	Lower	3/12	0.097 - 1.3	0.832	300	0
Endosulfan II	Upper	1/12	0.54	NA	47,000	0
Endosulfan Sulfate	Upper	3/12	0.32 - 1.60	0.937	47,000	0
	Lower	1/12	0.48	NA	300	0
Endrin	Upper	7/12	0.16 - 1.6	0.476	230	0
	Lower	5/12	0.29 - 0.7	0.485	400	0
Endrin aldehyde	Upper	4/12	0.14 - 3.3	2.035	230,000	0
	Lower	1/12	3.30	NA	400	0
Heptachlor	Upper	7/12	0.19 - 3.8	1.901	140	0
	Lower	3/12	0.079 - 0.34	0.223	60	0
Heptachlor epoxide	Upper	7/12	0.18 - 2.0	0.554	70	0
	Lower	2/12	0.25 - 0.34	0.295	60	0
Methoxychlor	Upper	2/12	1.3 - 6.9	4.1	39,000	0
	Lower	1/12	0.900	NA	62,000	0
Other Organic Compounds						
Total Petroleum Hydrocarbons (Units for TPH are mg/kg) (Upper Interval — 12 Samples plus 1 Duplicate/Lower Interval — 12 Samples plus 1 Duplicate)						
TPH	Upper	8/12	15.2 - 135.0	54.7	100	1
	Lower	10/12	12.4 - 67.6	33.5	NA	0

Table 10.4.3
Organic Compound Analytical Results for Soil
AOC 515 — Former Incinerator and AOC 519 — Former Boiler House

Compound	Sample Interval	Frequency of Detection	Range of Detection	Mean	RBC[a]	Number of Samples Exceeding RBC
Other Organic Compounds						
Herbicide Compounds (μg/kg)						
(Upper Interval — 1 Duplicate Sample [AOC 519]/Lower Interval — 1 Duplicate Sample [AOC 515])						
2,4,5-Trichlorophenoxyacetic acid	Upper	1/1	18.0	NA	78,000	0
2,4-Dichlorophenoxyacetic acid	Upper	1/1	55.0	NA	78,000	0
2,4,5-TP (Silvex)	Lower	1/1	1.7	NA	2,670	0
Organophosphorous Pesticide Compounds (μg/kg)						
(Upper Interval — 1 Duplicate Sample [AOC 519]/Lower Interval — 1 Duplicate Sample [AOC 515])						
Disulfoton	Lower	½	1.6	NA	2.6	0
Methyl parathion	Lower	½	4.2	NA	4.1	1
Parathion	Lower	½	8.6	NA	390	0
Sulfotep	Lower	½	2.6	NA	27	0
Dioxins (ng/kg)						
(Upper Interval — 1 Duplicate Sample [AOC 519]/Lower Interval — 1 Duplicate Sample [AOC 515])						
1234678-HpCDD	Lower	1/1	0.491	NA	NA	NA
1234678-HpCDF	Upper	1/1	0.615	NA	NA	NA
	Lower	1/1	0.872	NA	NA	NA
132789-HxCDF	Lower	1/1	0.541	NA	NA	NA
OCDD	Upper	1/1	1.67	NA	NA	NA
	Lower	1/1	2.05	NA	NA	NA
OCDF	Upper	1/1	0.865	NA	NA	NA
	Lower	1/1	1.59	NA	NA	NA
TEQ	Upper	1/1	0.015	NA	1,000	0
	Lower	1/1	0.071	NA	80	0

Notes:
[a] = Noncarcinogenic RBCs were adjusted to equate with a hazard quotient of 0.1.
[b] = These compounds are cPAHs and were multiplied by the appropriate BEF for comparison as BEQ.
All results are in μg/kg except for TPH which is in mg/kg and dioxins which are in ng/kg.

Table 10.4.4
Inorganic Analytical Results for Soil
AOC — 515 Former Incinerator and 519 — Boiler House
(Upper Interval — 12 Samples plus 1 Duplicate/Lower Interval — 12 Samples plus 1 Duplicate)

Analyte	Sample Interval	Frequency of Detection	Range of Detection (mg/kg)	Mean (mg/kg)	Reference Conc. (mg/kg)	Number of Samples Exceeding Reference
Aluminum	Upper	12/12	2,940 - 5,730	4,505.00	9,990	0
	Lower	12/12	2,230 - 4,030	3,132.50	23,700	0
Arsenic	Upper	6/12	1.6 -12.5	4.52	14.2	0
	Lower	2/12	0.40 - 0.53	0.47	14.1	0
Barium	Upper	12/12	12.3 - 102.0	45.61	77.2	3
	Lower	12/12	6.0 -18.0	10.30	68.5	0
Beryllium	Upper	2/12	0.39 - 0.46	0.43	ND	2
Cadmium	Upper	1/12	0.330	0.33	0.65	0
Calcium	Upper	12/12	906.0 - 15,900	5,266.58	NA	0
	Lower	12/12	104.0 - 1840	753.58	NA	0
Chromium	Upper	12/12	3.8 - 12.3	7.49	26.4	0
	Lower	12/12	3.30 - 5.60	4.34	12.5	0
Cobalt	Upper	12/12	0.35 - 6.00	1.60	3.22	3
	Lower	12/12	0.425 - 0.680	0.54	7.1	0
Copper	Upper	10/12	1.80 - 117.0	39.40	34.7	5
	Lower	6/12	0.88 - 2.90	1.70	42.2	0
Iron	Upper	12/12	2,350 - 11,900	4,197.50	NA	0
	Lower	12/12	1,7600 - 2,730	2,231.67	NA	0
Lead	Upper	12/12	2.80 - 522.0	149.15	330	3
	Lower	12/12	1.50 - 11.40	3.65	73.2	0
Magnesium	Upper	12/12	224.0 - 454.0	320.75	NA	0
	Lower	11/12	168.0 - 309.0	211.82	NA	0
Manganese	Upper	12/12	16.90 - 117.0	43.65	92.5	1
	Lower	12/12	11.30 - 26.90	18.40	106	0
Mercury	Upper	8/12	0.110 - 0.210	0.15	0.24	0
	Lower	1/12	0.110	0.11	0.30	0

Table 10.4.4
Inorganic Analytical Results for Soil
AOC — 515 Former Incinerator and 519 — Boiler House
(Upper Interval — 12 Samples plus 1 Duplicate/Lower Interval — 12 Samples plus 1 Duplicate)

Analyte	Sample Interval	Frequency of Detection	Range of Detection (mg/kg)	Mean (mg/kg)	Reference Conc. (mg/kg)	Number of Samples Exceeding Reference
Nickel	Upper	12/12	1.40 - 14.40	4.56	12.3	1
	Lower	12/12	0.880 - 1.80	1.37	16.7	0
Potassium	Upper	12/12	92.40 - 212.0	140.58	NA	0
	Lower	12/12	76.60 - 148.0	96.95	NA	0
Selenium	Upper	5/12	0.54 - 0.870	0.68	1.44	0
	Lower	3/12	0.530 - 0.580	0.55	2.90	0
Sodium	Upper	8/12	98.60 - 460.0	177.95	NA	0
	Lower	6/12	110.0 - 129.0	121.67	NA	0
Tin	Upper	6/12	1.40 - 148.0	48.35	2.95	5
	Lower	6/12	0.97 - 2.40	1.51	2.37	1
Vanadium	Upper	12/12	3.10 - 8.30	4.99	23.4	0
	Lower	12/12	2.20 - 4.20	2.98	56.9	0
Zinc	Upper	12/12	6.10 - 410.0	152.62	159	5
	Lower	12/12	3.70 - 11.20	5.90	243	0

Volatile Organic Compounds in Soil

Methylene chloride was detected in one upper interval sample; vinyl acetate was detected in the two upper interval and one lower interval samples. Neither compound was detected at a concentration exceeding its respective RBC.

Semivolatile Organic Compounds in Soil

Nine SVOCs were detected in upper interval samples. BaP was detected above its RBC of 88 μg/kg at location 515SB003. Five of the SVOCs detected are cPAHs; the BEQ was calculated for each sample where cPAHs were detected. The BEQs ranged from 4.35 μg/kg to 245.62 μg/kg. The only BEQ exceedance of the BaP RBC of 88 μg/kg was at location 515SB003.

Pesticides and PCBs in Soil

Seventeen pesticide compounds were detected in upper interval samples, and 13 were detected in lower interval samples; however, all were below their respective RBCs.

No PCBs were detected in soil samples from AOCs 515 or 519.

Other Organic Compounds in Soil

Other organic compounds include analytical groups that are not part of the standard analytical suite, including TPH analyses as well as the Appendix IX analytical suites for herbicides, organophosphorous pesticides, and dioxins.

Petroleum hydrocarbons were detected in eight upper interval samples with a maximum concentration of 135 mg/kg and a mean concentration of 54.7 mg/kg. Petroleum hydrocarbons were detected in 10 lower interval soil samples with a maximum concentration of 67.6 mg/kg and a mean concentration of 33.5 mg/kg. Only one upper interval sample exceeded the screening level of 100 mg/kg.

Three herbicide compounds were detected in the two duplicate soil samples submitted for Appendix IX analyses: 2,4,5-Trichlorophenoxyacetic acid (2,4,5-T) was detected in one upper interval sample; 2.4.5-TP (Silvex) was detected in one lower interval sample; and 2,4-dichlorophenoxyacetic acid (2,4-D) was detected in one upper interval soil sample. Neither compound was detected at a concentration exceeding its RBC.

Three organophosphorous pesticide compounds — disulfoton, methyl parathion, parathion, and sulfotep — were detected in the lower interval duplicate soil sample collected at AOC 515. The methyl parathion detection (4.2 μg/kg) exceeded its SSL (4.1 μg/kg). The organophosphorous pesticides were only analyzed for when duplicate samples were collected.

Dioxins were detected in both duplicate samples submitted for analysis (515CB00602 lower interval and 519CB00101 upper interval). The upper interval TEQ was calculated at 0.015 ng/kg, and the lower interval was at 0.071 ng/kg. Both are below their TCDD RBC and SSL of 1,000 ng/kg and 90 ng/kg respectively.

Inorganic Elements in Soil

Table 10.4.4 summarizes the inorganic analytical results for the soil samples collected at AOCs 515 and 519. Twenty-one analytes were detected in upper interval soil samples; nine exceeded their respective reference concentrations: barium, beryllium, cobalt, copper, lead, manganese, nickel, tin, and zinc. Of these analytes, barium, cobalt, copper, lead, manganese, and zinc were detected in more than half of the upper interval samples. Nineteen analytes were detected in the lower interval soil samples; only tin exceeded its reference concentration at one location.

Cyanide was not detected in soil samples collected from AOCs 515 or 519. Hexavalent chromium was detected at 1.19 mg/kg in the upper interval duplicate soil sample collected from AOC 519.

10.4.3 Fate and Transport of Contaminants

AOC 515, a former incinerator and paint shop, and AOC 519, a former boiler house, are currently a gravel parking area located an the east side of Building NH-55. For the purposes of the fate and transport assessment, AOCs 515 and 519 are combined based on their proximity. Migration pathways investigated for combined AOC 515 include soil-to-groundwater and surface soil-to-air.

Environmental media sampled as part of the combined AOC 515 RFI include surface soil and subsurface soil.

10.4.3.1 Soil-to-Groundwater Cross-Media Transport

Table 10.4.5 compares constituents found in surface and subsurface soil with groundwater protection risk-based soil screening levels and grid-based background reference concentrations. Four constituents (copper, lead, manganese, and tin) were detected in combined AOC 515 soil at concentrations above groundwater protection SSLs or background reference concentrations. TPH was detected in combined AOC 515 soil and could not be quantitatively evaluated regarding soil-to-groundwater migration in the absence of a groundwater protection SSL; however, concentrations were lower in the subsurface soil.

Inorganic elements were detected in combined AOC 515 surface soil above groundwater protection SSLs or background reference concentrations but were either not detected in subsurface soil or detected at concentrations below groundwater protection SSLs or background reference concentrations. Reference concentration exceedances for these elements were identified at AOC boring locations 1, 2, 3, 5, and 6 which are within or immediately adjacent to the former incinerator footprint. As such, it is reasonable to suspect that elevated levels may be associated with ash or paint overspray. Based on subsurface results, it is apparent that any deposition was exclusively surficial and has been soil attenuated. Although these findings suggest that potential isolated leaching in the soil column could occur, no significant effect on the AOC 515 shallow aquifer is expected.

10.4.3.2 Soil-to-Air Cross Media Transport

Table 10.4.6 lists the volatile organic compounds detected in surface soil samples collected at combined AOC 515 and corresponding soil-to-air volatilization screening levels. The maximum surface soil VOC concentration did not exceed its corresponding soil-to-air volatilization screening level. As a result, the soil-to-air migration pathway would not be expected to be significant at the site.

Table 10.4.5
Chemicals Detected in Surface Soil and Subsurface Soil
Comparison to Groundwater Protection SSLs and Background UTLs
NAVBASE-Charleston, Zone C, AOC 515 and AOC 519
Charleston, South Carolina

Parameter	Surface Soil Maximum Conc.	Subsurface Soil Maximum Conc.	Ground Water Protection SSL or UTL *	Soil Units	Soil Conc. Exceeds SSL or UTL
Aldrin	0.5	0.14	500	UG/KG	NO
Aluminum	5730	4030	28700	MG/KG	NO
Anthracene	55	ND	1200000	UG/KG	NO
Antimony	1.7	ND	5	MG/KG	NO
Arsenic	12.5	0.53	29	MG/KG	NO
Barium	102	18	1600	MG/KG	NO
Benzo(a)pyrene Equivalents					
Benzo(a)pyrene	190	ND	8000	UG/KG	NO
Benzo(a)anthracene	200	ND	2000	UG/KG	NO
Benzo(b)fluoranthene	310	ND	5000	UG/KG	NO
Beryllium	0.46	ND	63	MG/KG	NO
alpha-BHC	0.093	ND	0.5	UG/KG	NO
beta-BHC	1.9	0.32	3	UG/KG	NO
delta-BHC	0.17	ND	3	UG/KG	NO
gamma-BHC	0.089	ND	9	UG/KG	NO
Cadmium	0.33	ND	8	MG/KG	NO
Chromium	12.3	5.6	38	MG/KG	NO
Chromium (hexavalent)	1.19	ND	38	MG/KG	NO
Cobalt	6	0.68	7.1	MG/KG	NO
Copper	117	2.9	42.2	MG/KG	YES
2,4-D	55	ND	1880	UG/KG	NO
4,4'-DDD	11	0.4	16000	UG/KG	NO
4,4'-DDE	210	2.3	54000	UG/KG	NO
4,4'-DDT	150	0.96	32000	UG/KG	NO
Di-n-butylphthlate	49	ND	2300000	UG/KG	NO
Dieldrin	3.4	0.84	4	UG/KG	NO
Dioxin (TCDD TEQ)	0.015	0.071	4	PG/G	NO
Disulfoton	ND	1.6	5	UG/KG	NO
Endosulfan	2.53	1.3	18000	UG/KG	NO
Endrin	1.6	0.7	1000	UG/KG	NO
Endrin aldehyde	3.3	0.3	1000	UG/KG	NO
Fluoranthene	450	ND	430000	UG/KG	NO
Heptachlor	3.8	0.34	23000	UG/KG	NO
Lead	522	11.4	330	MG/KG	YES
Manganese	117	26.9	106	MG/KG	YES
Mercury	0.21	0.11	0.3	MG/KG	NO
Methoxychlor	6.9	0.9	160000	UG/KG	NO
Methylene chloride	15	ND	20	UG/KG	NO
Methyl parathion	ND	4.2	6	UG/KG	NO
Nickel	14.4	1.8	130	MG/KG	NO
Parathion	ND	8.6	8900	UG/KG	NO
Phenanthrene	290	ND	100000000	UG/KG	NO
Pyrene	390	ND	420000	UG/KG	NO
Selenium	0.87	0.58	5	MG/KG	NO
Sulfotepp	ND	2.6	55	UG/KG	NO
2,4,5-T	18	ND	450	UG/KG	NO

Table 10.4.5
Chemicals Detected in Surface Soil and Subsurface Soil
Comparison to Groundwater Protection SSLs and Background UTLs
NAVBASE-Charleston, Zone C, AOC 515 and AOC 519
Charleston, South Carolina

Parameter	Surface Soil Maximum Conc.	Subsurface Soil Maximum Conc.	Ground Water Protection SSL or UTL *	Soil Units	Soil Conc. Exceeds SSL or UTL
2,4,5-TP (Silvex)	1.7	ND	5300	UG/KG	NO
Tin	148	2.4	2.95	MG/KG	YES
Total Petroleum Hydrocarbon	135	67.6	NA	MG/KG	YES
Vanadium	8.3	4.2	600	MG/KG	NO
Vinyl acetate	8	11	17000	UG/KG	NO
Zinc	410	11.2	1200	MG/KG	NO

* - See Table 6-2
NA - Not available
ND - Not detected
SSL - Groundwater protection soil screening level
UTL - Grid-based background upper tolerance limit
MG/KG - Milligram per kilogram
UG/KG - Micrograms per kilogram

Table 10.4.6
Soil-to-Air Volatilization Screening Analysis
NAVBASE - Charleston Zone C, AOC 515 and AOC 519
Charleston, South Carolina

VOCs	Maximum Concentratio in Surface Soil	Soil to Air SSL *	Units	Exceeds SSL
Methylene chloride	0.015	13	MG/KG	NO

* - Soil-to-air RBCs were obtained from USEPA Soil Screening Guidance: Technical Background Document, May 1996

10.4.4 Human Health Risk Assessment

10.4.4.1 Site Background and Investigative Approach

AOCs 515 and 519 were investigated to assess soil possibly affected by past site activities. AOCs 515 and 519 were combined because of their proximity as well as suspected similar CPSSs. An incinerator that operated at AOC 515 in the 1920s was replaced by a paint shop in the 1930s. The waste disposal practices of this facility are unknown. Currently, the site is a gravel/asphalt parking area east of AOC 519, which was a boiler house for the Navy brig from 1922 until 1929. AOC 519 is currently a gravel/asphalt parking area east of Building NH-55. Thirteen samples were collected from the upper interval at AOC 515. Table 10.4.7 lists the analytical methods used for the corresponding samples.

10.4.4.2 COPC Identification

Soil

Based on the screening comparisons described in Section 7, this HHRA focuses on BEQs. Screening comparisons are shown in Table 10.4.8. BEQs, lead, and beryllium were identified as surface soil COPCs. All COPCs identified were reported at concentrations greater than screening values in AOC 515 samples only. As a result, all subsequent risk/hazard projections should be considered applicable to AOC 515. Therefore, the area of investigation discussed in this HHRA is limited to AOC 515, and AOC 519 was generally eliminated. No COPCs were added to this HHRA based on the Wilcoxon rank sum test. Results are presented in Section 5.

TPH was detected in eight surface soil samples collected at AOCs 515/519. The NAVBASE TPH screening level of 100 mg/kg was exceeded in one sample (519SB00201, 135 mg/kg).

Table 10.4.7
Methods Run at AOC 515 and AOC 519
Surface Soil

Site	Location	Metal	SVOA	VOA	Cn	Hexa	Diox	Oppe	Herb	Pest	Tph	Otin	Eng
515	B001	Y	Y	Y	Y					Y	IR		
515	B002	Y	Y	Y	Y					Y	IR		
515	B003	Y	Y	Y	Y					Y	IR		Y
515	B004	Y	Y	Y	Y					Y	IR		
515	B005	Y	Y	Y	Y					Y	IR		
515	B006	Y	Y	Y	Y					Y	IR		
515	B007		Y										
515	B008		Y										
519	B001	D	D	D	D	Y	Y	Y	Y	D	IR		
519	B002	Y	Y	Y	Y					Y	IR		
519	B003	Y	Y	Y	Y					Y	IR		
519	B004	Y	Y	Y	Y					Y	IR		
519	B005	Y	Y	Y	Y					Y	IR		
519	B006	Y	Y	Y	Y					Y	IR		

METHODS:

- Metal: TAL (Target Analyte List) Metals plus tin: Methods: 6000/7000 Series
- VOA: Volatile Organic Analysis: Method 8240
- SVOA: Semi-volatile Organic Analysis: Method 8270
- Cn: Cyanide (Soil: Method 9010, Water: Method 9012)
- Hexa: Hexavalent Chromium: Method 7195
- Diox: Dioxins
- Oppe: Organophosphate Pesticides: Method 8140
- Herb: Chlorinated Herbicides: Method 8150
- Pest: Chlorinated Pesticides: Method 8080
- Tph: Total Petroleum Hydrocarbons
- Otin: Organotin
- Eng: Engineering Parameters

KEY:

- Y: Analyzed for standard list
- D: Duplicate Analysis
- IR: Method 4181
- DR: Extraction Method 3550, GC Method 8100
- GR: Extraction Method 5030, GC Method 8015

Blank value indicates this method of analysis was not performed

Table 10.4.8
Summary of Chemicals Present in Site Samples, AOC 515 and AOC 519
Surface Soil
NAVBASE - Charleston, Zone C
Charleston, South Carolina

NAME	CONC UNITS	FREQ	DETECTS Min	DETECTS Max	DETECTS Avg	SCREENING Value	SCREENING # Over	SCREENING Source	NON-DETECTS Min	NON-DETECTS Max	BACKGROUND Value	BACKGROUND # Over
Carcinogenic PAHs												
B(a)P Equiv.	UG/KG	6 - 14	4.349	245.62	77.67	88	2		1345.06	1440.61		
Benzo(a)anthracene	UG/KG	6 - 14	42	200	91.33	880		C	690	740		
Benzo(b)fluoranthene	UG/KG	5 - 14	110	310	184.00	880		C	810	870		
Chrysene	UG/KG	6 - 14	49	220	107.83	88000		C	560	610		
Benzo(k)fluoranthene	UG/KG	5 - 14	130	440	232.00	8800		C	650	700		
Benzo(a)pyrene	UG/KG	3 - 14	39	190	102.33	88	1	C	690	740		
Dioxins												
Dioxin Equiv.	NG/KG	1 - 1	0.0087	0.0087	0.01	1000						
1234678-HpCDF	NG/KG	1 - 1	0.615	0.615	0.62							
OCDD	NG/KG	1 - 1	1.671	1.671	1.67							
OCDF	NG/KG	1 - 1	0.865	0.865	0.87							
Petroleum Hydrocarbons												
Petroleum Hydrocarbons, TPH	MG/KG	11 - 12	13.9	135	47.64	100	1		6.3	6.3		
Inorganics												
Aluminum (Al)	MG/KG	12 - 12	2940	5730	4505.00	7800		N			9990	
Antimony (Sb)	MG/KG	5 - 12	0.47	1.7	0.96	3.1		N	0.2	0.21	0.55	3
Arsenic (As)	MG/KG	6 - 12	1.6	12.5	4.52	0.43	6	C	0.35	2.1	14.2	
Barium (Ba)	MG/KG	12 - 12	12.3	102	45.61	550		N			77.2	3
Beryllium (Be)	MG/KG	2 - 12	0.39	0.46	0.43	0.15	2	C	0.17	0.43		
Cadmium (Cd)	MG/KG	1 - 12	0.33	0.33	0.33	3.9		N	0.03	0.56	0.65	
Calcium (Ca)	MG/KG	12 - 12	906	15900	5266.58	NA						
Chromium (Cr)	MG/KG	12 - 12	3.8	12.3	7.49	39		N			26.4	
Chromium (Hexavalent)	MG/KG	1 - 1	1.19	1.19	1.19	39		N				
Cobalt (Co)	MG/KG	12 - 12	0.35	6	1.60	470		N			3.22	3
Copper (Cu)	MG/KG	10 - 12	1.8	117	39.40	310		N	0.93	0.96	34.7	5
Iron (Fe)	MG/KG	12 - 12	2350	11900	4197.50	NA		N				
Lead (Pb)	MG/KG	12 - 12	2.8	522	149.15	400	1	j			330	3
Magnesium (Mg)	MG/KG	12 - 12	224	454	320.75	NA						

Table 10.4.8
Summary of Chemicals Present in Site Samples, AOC 515 and AOC 519
Surface Soil
NAVBASE - Charleston, Zone C
Charleston, South Carolina

NAME	CONC UNITS	FREQ	DETECTS Min	DETECTS Max	DETECTS Avg	SCREENING Value	SCREENING # Over	SCREENING Source	NON-DETECTS Min	NON-DETECTS Max	BACKGROUND Value	BACKGROUND # Over
Carcinogenic PAHs												
Manganese (Mn)	MG/KG	12 - 12	16.9	117	43.65	180		N			92.5	1
Mercury (Hg)	MG/KG	8 - 12	0.11	0.21	0.15	2.3		N	0.1	0.11	0.24	
Nickel (Ni)	MG/KG	12 - 12	1.4	14.4	4.56	160		N			12.3	1
Potassium (K)	MG/KG	12 - 12	92.4	212	140.58	NA						
Selenium (Se)	MG/KG	5 - 12	0.54	0.87	0.68	39		N	0.46	0.48	1.44	
Sodium (Na)	MG/KG	8 - 12	98.6	460	177.95	NA			104	241		
Tin (Sn)	MG/KG	6 - 12	1.4	148	48.35	4700			1.4	2.7	2.95	5
Vanadium (V)	MG/KG	12 - 12	3.1	8.3	4.99	55		N			23.4	
Zinc (Zn)	MG/KG	12 - 12	6.1	410	152.62	2300		N			159	5
Chlorinated Pesticides												
Aldrin	UG/KG	4 - 12	0.11	0.5	0.27	38		C	1.1	1.1		
beta-BHC	UG/KG	3 - 12	0.65	1.9	1.22	350		C	1.1	1.1		
alpha-BHC	UG/KG	1 - 12	0.093	0.093	0.09	100		C	1.1	1.1		
delta-BHC	UG/KG	1 - 12	0.17	0.17	0.17	100		I	1.1	1.1		
gamma-BHC (Lindane)	UG/KG	1 - 12	0.089	0.089	0.09	490		C	1.1	1.1		
2,4-D	UG/KG	1 - 1	55	55	55.00	78000		N				
4,4'-DDD	UG/KG	6 - 12	0.69	11	4.82	2700		C	3.7	3.8		
4,4'-DDE	UG/KG	8 - 12	16	210	73.63	1900		C	3.7	3.8		
4,4'-DDT	UG/KG	8 - 12	4.9	150	42.86	1900		C	3.7	3.8		
Dieldrin	UG/KG	2 - 12	0.77	3.4	2.09	40		C	1.6	1.6		
Endosulfan I	UG/KG	5 - 12	0.14	1.2	0.73	47000		N	1.6	1.6		
Endosulfan sulfate	UG/KG	1 - 12	1.6	1.6	1.60	47000		N	2.1	2.2		
Endrin	UG/KG	5 - 12	0.16	2.6	0.97	2300		N	2.6	2.7		
Endrin aldehyde	UG/KG	4 - 12	0.14	3.3	2.04	2300		h	1.1	1.1		
Heptachlor	UG/KG	5 - 12	0.8	3	1.74	140		C	1.1	1.1		
Heptachlor epoxide	UG/KG	5 - 12	0.18	2	0.69	70		C	1.1	1.1		
Methoxychlor	UG/KG	1 - 12	6.9	6.9	6.90	39000		N	3.7	5.3		
2,4,5-T	UG/KG	1 - 1	18	18	18.00	78000		N				
Semivolatile Organics												

Table 10.4.8
Summary of Chemicals Present in Site Samples, AOC 515 and AOC 519
Surface Soil
NAVBASE - Charleston, Zone C
Charleston, South Carolina

NAME	CONC UNITS	FREQ	DETECTS Min	DETECTS Max	DETECTS Avg	SCREENING Value	SCREENING # Over	SCREENING Source	NON-DETECTS Min	NON-DETECTS Max	BACKGROUND Value	BACKGROUND # Over
Carcinogenic PAHs												
Anthracene	UG/KG	1 - 14	55	55	55.00	2300000		N	770	840		
Di-n-butylphthalate	UG/KG	1 - 14	49	49	49.00	780000		N	810	880		
Fluoranthene	UG/KG	6 - 14	52	450	163.83	310000		N	960	1000		
Phenanthrene	UG/KG	4 - 14	49	290	120.75	310000		f	650	700		
Pyrene	UG/KG	6 - 14	50	390	148.00	230000		N	760	820		
Volatile Organics												
Methylene chloride	UG/KG	1 - 12	15	15	15.00	85000		C	21	32		
Vinyl acetate	UG/KG	2 - 12	1	8	4.50	7800000		N	21	22		

Notes:
- * Retained as a chemical of potential concern
- C The RBC is based on carcinogenic effects
- N The RBC is based on noncarcinogenic effects
- j Screening level is set equal to the soil action level
- l The RBC for gamma-BHC is used as a surrogate
- h The RBC for endrin is used as a surrogate
- f The RBC for fluoranthene is used as a surrogate

Groundwater

Groundwater was neither sampled nor assessed at AOCs 515 and 519 because groundwater was not identified as a potential pathway.

10.4.4.3 Exposure Assessment

Exposure Setting

The site occupies approximately 250,000 square feet of gravel/asphalt parking area. This site is near an administrative building, and current exposure would be limited to employees walking to and from their cars and during NAVBASE maintenance activities. The future use of combined AOC 515 is unknown, although it overlaps sections of NAVBASE currently projected as a community support and residential area in base reuse plans.

Potentially Exposed Populations

Potentially exposed populations are current and future site workers. Additional potentially exposed populations are future site residents. Future site resident and worker exposure scenarios were addressed in this risk assessment. The hypothetical future site worker scenario assumed continuous exposure to surface soil conditions. Current site workers' exposure would be less than that assumed for the hypothetical future site worker scenario because of their limited soil contact. Therefore, future worker assessment is considered to be protective of current site users. The future site resident scenario was built on the premise that existing buildings and gravel parking areas would be removed and replaced with dwellings.

Exposure Pathways

Exposure pathways for the site workers are dermal contact and incidental ingestion of surface soil. The exposure pathways for future residential land use are the same as those for the future site worker. In addition, the hypothetical future site worker scenario assumed continuous exposure to surface soil conditions. Uniform exposure was assumed for all sample locations. Table 10.4.9 justifies exposure pathways assessed in this HHRA.

Exposure Point Concentrations

As discussed in Section 7 of this HHRA, UCLs were calculated for datasets consisting of at least 10 samples. Although 14 surface soil samples delineate AOCs 515/519, the maximum concentration reported for BEQs was used as the EPC to estimate exposure. BEQs were reported exclusively at AOC 515, which occupies approximately 10,000 square feet. Therefore, UCLs were not calculated because eight samples delineate AOC 515. Approximately 20% of the one-half acre exposure area around AOC 515 is impacted, and an FI/FC of 0.2 was applied to the exposure estimates assuming exposure to the AOI only. This factor was applied to the maximum reported concentration to estimate RME exposure to BEQs reported in surface soil. Of the 13 reported concentrations, BEQs exceed the corresponding RBC at only one sample location. All sample locations where BEQs were reported were covered with asphalt, and BEQs are components of asphalt. Sampling directly beneath asphalt confounds the issue of possible sources of BEQs, and both the incinerator and asphalt could be BEQ sources. The RME exposure for BEQ is an overestimate.

Beryllium was reported in two of eight samples at AOC 515, at an FI/FC of 0.2 based on the area defined. The FI/FC was used to adjust the beryllium exposure estimates.

Quantification of Exposure

Soil

CDIs for ingestion and dermal contact with surface soil are in Tables 10.4.10 and 10.4.11.

Table 10.4.9
Exposure Pathways Summary — AOC 515
NAVBASE — Zone C
Charleston, South Carolina

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Current Land Uses			
Current Site Users/Maintenance	Air, Inhalation of gaseous contaminants emanating from soil	No	No significant VOC concentrations were reported in surface soils, and portions of the site area are paved/covered by buildings.
	Air, Inhalation of chemicals entrained in fugitive dust	No	Portions of the site area are paved/covered by buildings, which limits fugitive dust generation.
	Shallow groundwater, Ingestion of contaminants during potable or general use	No	Shallow groundwater is not currently used as a source of potable or non-residential water at AOC 515.
	Shallow groundwater, Inhalation of volatilized shallow groundwater contaminants	No	Shallow groundwater is not currently used as a source of potable or non-residential water at AOC 515.
	Soil, Incidental ingestion	No (Qualified)	Future land use assessment is considered to be protective of current receptors.
	Soil, Dermal contact	No (Qualified)	Future land use assessment is considered to be protective of current receptors.
Future Land Uses			
Future Site Residents (Child and Adult) and Future Site Worker	Air, Inhalation of gaseous contaminants emanating from soil	No	No significant VOC concentrations were reported in surface soils, and portions of the site area are paved/covered by buildings.
	Air, Inhalation of chemicals entrained in fugitive dust	No	Portions of the site area are paved/covered by buildings, which limits fugitive dust generation.
	Shallow groundwater, Ingestion of contaminants during potable or general use	No	No groundwater sampling was performed in conjunction with the 515 investigation.
	Shallow groundwater, Inhalation of volatilized contaminants during domestic use	No	No groundwater sampling was performed in conjunction with the 515 investigation.
	Soil, Incidental ingestion	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Soil, Dermal contact	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Wild game or domestic animals, Ingestion of tissue impacted by media contamination	No	Hunting/taking of game and/or raising livestock is prohibited within the Charleston, South Carolina, City Limits.
	Fruits and vegetables, Ingestion of plant tissues grown in media	No	The potential for significant exposure via this pathway is low relative to that of other exposure pathways assessed.

Table 10.4.10
Chronic Daily Intakes (CDI)
Incidental Ingestion of Surface Soil (0-1')
AOCs 515 and 519 Zone C
Naval Base Charleston
Charleston, SC

Chemical	TEF	Fraction Ingested fro Contaminate Source	Exposure Point Concentration (mg/kg)	Potential Future Resident adult H-CDI (mg/kg-day)	Potential Future Resident child H-CDI (mg/kg-day)	Potential Futur Resident lwa C-CDI (mg/kg-day)	Potential Curren Worker adult H-CDI (mg/kg-day)	Potential Current Worker adult C-CDI (mg/kg-day)
Benzo(a)pyrene Equival	1	0.2	0.246	6.73E-08	6.28E-07	7.69E-08	2.40E-08	8.58E-09
Beryllium	NA	0.2	0.46	1.26E-07	1.18E-06	1.44E-07	4.50E-08	1.61E-08
Lead	NA	1	522.0	7.15E-04	6.67E-03	8.17E-04	2.55E-04	9.12E-05

NOTES:

TEF toxic equivalency factor relative to Benzo(a)pyrene
lwa lifetime weighted average; used to calculate carcinogenic CDI, RAGS Parts A and B
CDI Chronic Daily Intake in mg/kg-day
H-CDI CDI for hazard quotient
C-CDI CDI for excess cancer risk
* Reflects the estimated fraction of the site impacted by the corresponding COPC.

Table 10.4.11
Chronic Daily Intakes (CDI)
Dermal Contact with Surface Soil (0-1')
AOCs 515 and 519 Zone C
Naval Base Charleston
Charleston, SC

Chemical	TEF	Adjusted Exposure Point Concentration (mg/kg)	Fraction Contacted fro Contaminated Source *	Dermal Absorption Factor (unitless)	Potential Future Resident adult H-CDI (mg/kg-day)	Potential Future Resident child H-CDI (mg/kg-day)	Potential Futur Resident lwa C-CDI (mg/kg-day)	Potential Curren Worker adult H-CDI (mg/kg-day)	Potential Current Worker adult C-CDI (mg/kg-day)
Benzo(a)pyrene Equival	1	0.246	0.2	0.01	2.76E-08	9.11E-08	1.73E-08	1.97E-08	7.04E-09
Beryllium	NA	0.46	0.2	0.001	5.17E-09	1.71E-08	3.23E-09	3.69E-09	1.32E-09
Lead	NA	522	1	0.001	2.93E-05	9.68E-05	1.83E-05	2.09E-05	7.48E-06

NOTES:

TEF Toxic Equivalency Factor relative to Benzo(a)pyrene
CDI Chronic Daily Intake in mg/kg-day
H-CDI CDI for hazard quotient
C-CDI CDI for excess cancer risk
- The dermal absorption factor was applied to the exposure point concentration to reflect the different trans-dermal migration of inorganic versus organic chemicals
* Reflects the estimated fraction of the site impacted by the corresponding COPC.

10.4.4.4 Toxicity Assessment

Toxicity assessment terms and methods are discussed in Section 7 of this report. In the following paragraphs, toxicological information specific to each COPC identified at combined AOC 515 and brief toxicological profiles are presented and discussed. Table 10.4.12 presents the information used to quantify risk and hazard associated with soil COPCs.

Polyaromatic hydrocarbons or BaP equivalents include the following list of COPCs:

Benzo(a)anthracene	TEF	0.1
Benzo(b)fluoranthene	TEF	0.1
Dibenz(a,h)anthracene	TEF	1.0
Benzo(k)fluoranthene	TEF	0.01
Benzo(a)pyrene	TEF	1.0
Indeno(1,2,3-cd)pyrene	TEF	0.1
Chrysene	TEF	0.001

Some PAHs are toxic to the liver, kidney, and blood. However, the toxic effects of the PAHs above have not been well established. There are no RfDs for the PAHs above due to a lack of data. All PAHs listed above are classified by USEPA as B2 carcinogens, and their carcinogenicity is addressed relative to that of BaP, having an oral SF 7.3 $(mg/kg\text{-}day)^{-1}$. TEFs, also set by USEPA, are multipliers that are applied to the detected concentrations, which are subsequently used to calculate excess cancer risk. These multipliers are discussed further in the exposure and toxicity assessment sections. Most carcinogenic PAHs have been classified as such due to animal studies using large doses of purified PAHs. There is some doubt as to the validity of these listings, and the SFs listed in USEPA's RBC table are provisional. However, these PAHs are carcinogens when the exposure involves a mixture of other carcinogenic substances (e.g., coal tar, soot, cigarette smoke, etc.). As listed in IRIS (search data June 28, 1995), the basis for the BaP B2 classification is a lack of human data specifically linking BaP to a carcinogenic effect.

Table 10.4.12
Toxicological Database Informatio
for Chemicals of Potential Concer
AOCs 515 and 519
NAVBASE Charleston, Zone C

Non-Carcinogenic Toxicity Data

Chemical	Oral Reference Dose (mg/kg/day)		Confidence Level	Critical Effect	Uncertainty Factor Oral	Inhalation Reference Dose (mg/kg/day)	Confidence Level	Critical Effect	Uncertainty Factor Inhalation
Benzo(a)pyrene Equivalents	ND				ND	ND			ND
Beryllium	0.005	a	L	microscopic organ changes	100	ND			ND
Lead	ND				ND	ND			ND

NOTES:

a Integrated Risk Information System (IRIS)
b Health Effects Assessment Summary Tables (HEAST)
c HEAST alternative method
d USEPA Region III Screening Tables
e EPA Environmental Criteria and Assessment Office - Cincinnati (provisional)
f Withdrawn from IRIS or HEAST
NA Not applicable or not available
ND Not determined due to lack of information

Table 10.4.12
Toxicological Database Informatio
for Chemicals of Potential Concer
AOCs 515 and 519
NAVBASE Charleston, Zone C

Carcinogenic Toxicity Data

Chemical	Oral Slope Factor [(mg/kg/day)]-1		Inhalation Slope Factor [(mg/kg/day)]-1		Weight of Evidence	Tumor Type
Benzo(a)pyrene Equivalents	7.3	a			B2	mutagen
Beryllium	4.3	a	8.4	a	B2	osteosarcoma
Lead	ND		ND		B2	various

However, multiple animal studies in many species demonstrate BaP to be carcinogenic by numerous routes.

BaP has produced positive results in numerous genotoxicity assays. At the June 1992 CRAVE Work Group meeting, a revised risk estimate for BaP was verified. This section provides information on three aspects of the carcinogenic risk assessment for the agent in question: the USEPA classification and quantitative estimates of exposure. The classification reflects a weight-of-evidence judgment of the likelihood that the agent is a human carcinogen. The quantitative risk estimates are presented in application of a low-dose extrapolation procedure and presented as the risk per mg/kg-day. The unit risk is the quantitative estimate in terms of either risk per μg/L drinking water or risk per $\mu g/m^3$ air breathed. The third form in which risk is presented is drinking water or air concentration providing cancer risks of 1 in 10,000 or 1 in 1,000,000. The Carcinogenicity Background Document provides details on the carcinogenicity values found in IRIS. Users are referred to the Oral Reference Dose and Reference Concentration sections for information on long-term toxic effects other than carcinogenicity.

As listed in IRIS (search date June 28, 1995), the basis for the dibenz(a,h)anthracene and benzo(b)fluoranthene B2 classification is no human data but sufficient data from animal bioassays. Benzo(b)fluoranthene produced tumors in mice after lung implantation, intraperitoneal or subcutaneous injection, and skin painting. As listed in IRIS (search date June 28, 1995), the basis for the benzo(a)anthracene B2 classification is no human data but sufficient data from animal bioassays. Benzo(a)anthracene produced tumors in mice exposed by gavage; intraperitoneal, subcutaneous, or intramuscular injection; and topical application. Benzo(a)anthracene produced mutations in bacteria and in mammalian cells, and transformed mammalian cells in culture. As listed in IRIS (search date June 28, 1995) the basis for the benzo(k)fluoranthene B2 classification is no human data but sufficient data from animal bioassays. Benzo(k)fluoranthene produced tumors after lung implantation in mice and when administered with a promoting agent in skin-painting studies. Equivocal results have been found in a lung adenoma assay in mice. Benzo(k)fluoranthene is mutagenic in bacteria (Klaassen et al. 1986).

Other PAHs — those not classified by USEPA as carcinogens — are toxic to the liver, kidney and blood. This group of PAHs includes compounds such as pyrene, acenaphthene, acenaphthylene, benzo(g,h,i)perylene, and phenanthrene. USEPA determined RfDs for only two of these compounds: pyrene's RfDo of 0.03 mg/kg-day is also used as a surrogate RfDo for phenanthrene. The RfDo for acenaphthene was 0.06 mg/kg-day.

Lead has been classified as a group B2 carcinogen by USEPA based on animal data. No RfD or SF has been set by USEPA. However, an action level for soil protective of child residents has been proposed by USEPA Region IV, 400 mg/kg. USEPA's OSWER has recommended a 1,000 mg/kg cleanup standard for industrial properties. USEPA's Office of Water has established a treatment technique action level of 15 μg/L. As listed in IRIS (search date October 17, 1995), the basis for classification is sufficient animal evidence. Ten rat bioassays and one mouse assay have shown statistically significant increases in renal tumors with dietary and subcutaneous exposure to several soluble lead salts. Animal assays provide reproducible results in several laboratories, in multiple rat strains with some evidence of multiple tumor sites. Shortterm studies show that lead affects gene expression. Human evidence is inadequate. An RfD and an SF have not been set because of the confounding nature of lead toxicity. Lead can accumulate in bone marrow, and effects have been observed in the CNS, blood, and mental development of children. RfDs are based on the assumption that a threshold must be exceeded to result in toxic effects (other than carcinogenicity). Once lead accumulates in the body, other influences cause the actual levels in the blood to fluctuate — sometimes the lead is attached to binding sites; sometimes lead is free flowing. If an exposed individual has previously been exposed to lead, this individual could lose weight and set fat-bound lead free. This fluctuation and lack of previous lead exposure data are two of the reasons lead effects are difficult to predict (Klaassen et al., 1986).

Beryllium exposure via the inhalation route can cause inflammation of the lungs, a condition known as Acute Beryllium Disease, as a result of short-term exposure to high concentrations. Removal from exposure reverses symptoms. Chronic exposure to much lower levels of beryllium or beryllium oxide by inhalation has been reported to cause chronic beryllium disease, with symptoms including shortness of breath, scarring of the lungs, and berylliosis, which is noncancerous growths in the lungs of humans. Both forms of beryllium disease can be fatal, depending on the severity of the exposure. Additionally, a skin allergy may develop when soluble beryllium compounds come into contact with the skin of sensitized individuals (Gradient, 1991). An oral RfD of 0.0054 mg/kg-day has been set for beryllium based on a chronic oral bioassay (rats were the study species) which determined no adverse effect occurs at 0.54 mg/kg-day. Beryllium has been classified by USEPA as a group B2 carcinogen based on animal studies. It has been shown to induce lung cancer via inhalation in rats and monkeys, and to induce osteosarcomas in rabbits via intravenous or intramedullary injection. Human epidemiology studies of beryllium are considered inadequate. As listed in IRIS (search date June 28, 1995), the basis for the classification is that beryllium has been shown to induce lung cancer via inhalation in rats and monkeys and to induce osteosarcomas in rabbits via intravenous or intramedullary injection. Human epidemiology studies are considered inadequate. An inhalation slope factor of 8.4 $(mg/kg\text{-}day)^{-1}$ and an oral SF of 4.3 $(mg/kg\text{-}day)^{-1}$ have been set by USEPA. As listed in IRIS (search date June 28, 1995), the critical effect of this chemical is no adverse effect. The uncertainty factor was 100 and the modifying factor was 1. The IRIS RfD in drinking water is 0.005 mg/kg-day.

10.4.4.5 Risk Characterization

Surface Soil Pathways

Exposure to surface soil onsite was evaluated under both residential and industrial (site worker) scenarios. For these scenarios, the incidental ingestion and dermal contact exposure pathways were evaluated. For noncarcinogenic contaminants evaluated for future site residents, hazard was computed separately to address child and adult exposure. Tables 10.4.13 and 10.4.14 present the estimated carcinogenic risks and/or HQs associated with the incidental ingestion of and dermal contact with site surface soil, respectively.

Hypothetical Site Residents

The ingestion ILCR (based on adult and child lifetime weighted average) for AOC 515 surface soil is 1E-6. The dermal pathway ILCR is 3E-7. BEQs and beryllium were the only contributors for each pathway. All estimates of HIs were less than 0.01 for this exposure pathway.

Hypothetical Site Workers

Site worker ILCR was estimated to be 1E-7 for both ingestion and dermal contact pathways. BEQs and beryllium were the only contributors to each pathway. All estimates of HIs were less than 0.01 for this exposure pathway.

Most of the combined AOC 515 area is covered by gravel/asphalt or by buildings, and BEQs are commonly detected in asphalt. Currently, soil exposure is limited to the parking area and soil surrounding the buildings, and continuous, chronic exposure to surface soil would be limited to maintenance activities and pedestrians parking their cars near the administrative building if site conditions are not altered.

Lead Toxicity

At AOC 515, one surface soil sample contained lead at concentrations exceeding the residential cleanup goal of 400 mg/kg (515SB00501). The mean lead concentrations at AOC 515 was calculated to be 290 mg/kg. Because the means falls below the residential cleanup goal, chronic exposures are not expected to pose a significant health threat to hypothetical future child residents.

Table 10.4.13
Hazard Quotients and Incremental Lifetime Cancer Risks
Incidental Surface Soil Ingestion
AOCs 515 and 519 Zone C
Naval Base Charleston
Charleston, SC

Chemical	Oral RfD Used (mg/kg-day)	Oral SF Used (mg/kg-day)-1	Potential Future Resident adult Hazard Quotient	Potential Future Resident child Hazard Quotient	Potential Futur Resident lwa ILCR	Potential Curren Worker adult Hazard Quotient	Potential Current Worker adult ILCR
Benzo(a)pyrene Equivale	NA	7.3	ND	ND	5.6E-07	ND	6.3E-08
Beryllium	0.005	4.3	0.00003	0.00024	6.2E-07	9.0E-06	6.9E-08
Lead	NA	NA	ND	ND	ND	ND	ND
SUM Hazard Index/ILCR			0.00003	0.0002	1E-06	0.000009	1E-07

NOTES:

NA Not available
ND Not Determined due to lack of available information
lwa lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime excess Cancer Risk

Table 10.4.14
Hazard Quotients and Incremental Lifetime Cancer Risks
Dermal Contact With Surface Soil
AOCs 515 and 519 Zone C
Naval Base Charleston
Charleston, SC

Chemical	Dermal Adjustment	Oral RfD Used (mg/kg-day	Oral SF Used (mg/kg-day)-1	Potential Future Resident adult Hazard Quotient	Potential Future Resident child Hazard Quotient	Potential Futu Resident lwa ILCR	Potential Curren Worker adult Hazard Quotient	Potential Current Worker adult ILCR
Benzo(a)pyrene Equiv	0.5	NA	14.6	ND	ND	2.5E-07	ND	1.0E-07
Beryllium	0.2	0.001	21.5	5.2E-06	1.7E-05	7.0E-08	3.7E-06	2.8E-08
Lead	0.2	NA	NA	ND	ND	ND	ND	ND
SUM Hazard Index/ILCR				0.000005	0.00002	3E-07	0.000004	1E-07

NOTES:

NA Not available
ND Not Determined due to lack of available information
lwa lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime excess Cancer Risk
- Dermal to absorbed dose adjustment factor is applied to adjust for Oral SF and RfD (i.e., the oral RfD is based on oral absorption efficiency which should not be applied to dermal exposure and dermal CDI)

COCs Identified

COCs are identified based on cumulative (all pathways) risk and hazard projected for this site. USEPA has established a generally acceptable risk range of 1E-4 to 1E-6, and a HI threshold of 1.0 (unity). In this HHRA, a COC was considered to be any chemical contributing to a cumulative risk level of 1E-6 or one whose HQ exceeds 0.1. For carcinogens, this approach is relatively conservative, because a cumulative risk level of 1E-4 (and individual ILCR of 1E-6) is recommended by USEPA Region IV as the trigger for establishing COCs. The COC selection method presented was used to provide a more comprehensive evaluation of chemicals contributing to carcinogenic risk or noncarcinogenic hazard during the RGO development process.

Surface Soil

Hypothetical Site Residents (Future Land Use)

No COCs were identified for this scenario based on the sum ILCR or HI.

Hypothetical Site Workers (Future Land Use)

No COCs were identified for this scenario based on the sum ILCR or HI.

No COPCs or COCs would be identified at AOC 519.

10.4.4.6 Risk Uncertainty

Characterization of Exposure Setting and Identification of Exposure Pathways

The potential for high bias is introduced through the exposure setting and pathway selection due to the highly conservative assumptions (i.e., future residential use) recommended by USEPA Region IV when assessing potential future and current exposure. The exposure assumptions made in the site worker scenario are highly protective and would tend to overestimate exposure. Under current site use conditions, workers are infrequently exposed to surface soil when performing maintenance activities, exiting or entering parked cars, or walking across the site. Most of the area is covered by either a gravel/asphalt parking area or by buildings.

Residential use of the site could occur based on current reuse plans. The reuse plans schedule combined AOC 515 to be used as a community support area/residential property. If this area is used as a residential site, the buildings would be demolished, the parking area surface removed, and surface soil conditions would likely change — the soil could be covered with landscaping soil and/or a house. Consequently, exposure to current surface soil conditions would not be likely under a true future residential scenario. These factors indicate that exposure pathways assessed in this HHRA would generally overestimate the risk and hazard posed to site workers and future site residents.

Determination of Exposure Point Concentrations

The maximum concentration reported for BEQs and beryllium were used as the EPCs for surface soil. As a result, the quantification of exposure does not account for potential variability in the contaminant concentrations in corresponding matrices.

Frequency of Detection and Spatial Distribution

The use of the maximum concentration as an EPC is questionable for the COCs at this site, and the calculated risk and hazard could be skewed up or down because of the low frequency of detection. The biased sampling approach would tend to skew exposure estimates high.

BEQs reported in surface soil at AOC 515 deserve further mention because they were detected in only five of the eight AOC 515 samples, and BEQs were not detected in AOC 519 samples. The BEQ at only one of the AOC 515 locations exceeded the residential RBC. As a result, the potential for chronic exposure at the EPC is considered low. An FI/FC of 0.2 was used to adjust exposure estimates to account for the limited extent of BEQs. The FI/FC is multiplied by the corresponding CDI, and the resulting CDI is considered to be adjusted for FI/FC. The maximum reported BEQ concentration was adjusted by the FI/FC, and site-wide exposure was assumed. Therefore, site-wide risk projected in this assessment for site workers is considered an overestimate. Alternatively, exposure calculated for the AOI defined by BEQs contains less uncertainty and is a better estimate of RME exposure (within the limited area).

Beryllium distribution was at AOC 515 only, and only two detections were reported. Both concentrations exceeded the beryllium RBC but were within the detection limit accuracy range of background detections. Because the cumulative ingestion and dermal ILCR estimate for beryllium exceeded 1E-6, it was identified as a COC.

Quantification of Risk/Hazard

As indicated by the discussions above, the uncertainty inherent in the risk assessment process is great. In addition, many site-specific factors affecting the uncertainty of this assessment would upwardly bias the risk and hazard estimates. Exposure pathway-specific sources of uncertainty are discussed below.

Soil

Of the CPSSs screened and eliminated from formal assessment because they did not exceed the corresponding RBCs, none was reported at a concentration within 10% of its RBC. This minimizes the likelihood of potentially significant cumulative risk/hazard based on the eliminated CPSSs. Arsenic and manganese concentrations exceeded the corresponding RBCs, and these elements were eliminated based on the comparison to reference concentrations.

BEQs' components are constituents of asphalt and their presence could be related to adjacent parking surfaces.

Because the future land use of combined AOC 515 is unknown, both the worker and residential exposure scenarios were assessed in this HHRA. As previously discussed, these scenarios would likely overestimate risk and/or hazard, especially under RME assumptions. An individual map was not produced for this site.

The CT assumption for residential exposure duration is nine years compared to the 30-year assumption for RME. This change alone would result in a 66.7% reduction in risk and hazard estimates. If all other exposure assumptions remain fixed, application of the CT exposure duration would result in risk projections below the USEPA acceptable risk threshold of 1E-6.

10.4.4.7 Risk Summary

The risk and hazard posed by contaminants at combined AOC 515 were assessed for the hypothetical RME site worker and the hypothetical RME future site resident. In surface soil, the incidental ingestion and dermal contact pathways were assessed in this HHRA. Table 10.4.15 summarizes risk and hazard for each exposure pathway and exposure scenario.

10.4.4.8 Remedial Goal Options

Soil

Because no COCs identified in this HHRA, RGO development was not warranted.

10.4.5 Corrective Measures Considerations

No further action is required based on the analytical results and risk assessment. No COCs were identified.

Table 10.4.15
Summary of Risk and Hazard for AOCs 515 and 519
NAVBASE - Charleston Zone C
Charleston, South Carolina

Medium	Exposure Pathway	HI (Adult)	HI (Child)	ILCR (LWA)	HI (Worker)	ILCR (Worker)
Surface Soil	Incidental Ingestion	0.00003	0.00024	1E-06	0.00001	1E-07
	Dermal Contact	0.000005	0.00002	3E-07	0.000004	1E-07
Sum of All Pathways		0.00003	0.0003	2E-06	0.00001	3E-07

Notes:
ND indicates not determined due to the lack of available risk information.
ILCR indicates incremental excess lifetime cancer risk
HI indicates hazard index

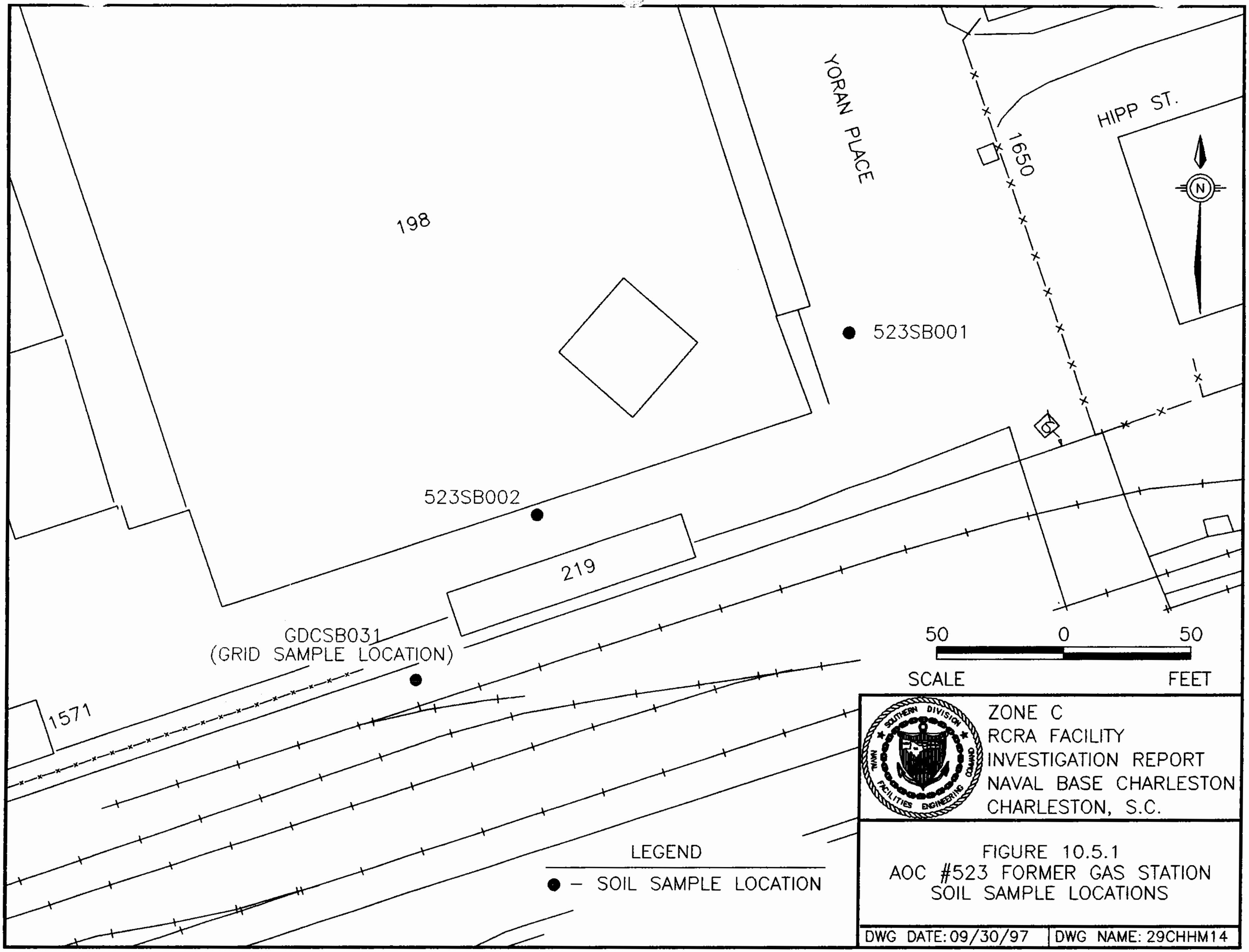
10.5 AOC 523 – Former Gas Station

AOC 523 (M-1234) operated as a gas station from 1958 until 1962. It is unknown if an underground storage tank (UST) is present. This site is covered by the southeast portion of Building 198 (Figure 10.5.1). A CSI was performed at AOC 523 to identify impacts, if any, to soil or groundwater from possible petroleum releases from a UST or other unknown releases onsite. Potential contaminants include petroleum hydrocarbons (gasoline, wastes oil, etc.).

10.5.1 Soil Sampling and Analysis

Soil was sampled at AOC 523 in accordance with the *Final Zone C RFI Work Plan,* (E/A&H 1995) and the procedures outlined in Section 3 of this report. Soil sampling was completed in a single round. Sampling locations are shown on Figure 10.5.1. The work plan required collecting soil samples from four locations, and installing monitoring wells at two of these locations. The two remaining locations were to be within Building 198; however, no samples were collected. The placement of these locations was to be determined based on results of the utility survey, which was inconclusive in determining where the UST had been located or if it was still in place. Data produced from soil samples collected without a clear relationship to a source (the UST) would be useless.

Four soil samples were collected from two locations — two from the upper interval and two from the lower interval. Sample locations were based on review of historical maps of the area, and were placed as near as possible to areas most likely impacted if a release occurred. Samples were analyzed for VOCs, SVOCs, pesticide/PCBs, metals, cyanide, and TPH at DQO Level III. One duplicate soil sample was submitted for Appendix IX analyses at DQO Level IV, which includes the parameters listed above as well as herbicides, hexavalent chromium, organophosphorous pesticides, and dioxins. Table 10.5.1 summarizes the soil sampling and analysis.



ZONE C
RCRA FACILITY
INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 10.5.1
AOC #523 FORMER GAS STATION
SOIL SAMPLE LOCATIONS

DWG DATE: 09/30/97 | DWG NAME: 29CHHM14

Table 10.5.1
AOC 523 — Former Gas Station
Soil Sampling and Analysis

Interval	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
Upper	4	2	Standard Suite[a], TPH	Standard Suite[a], TPH	Two locations not sampled; utility survey was inconclusive.
Lower	4	2	Standard Suite[a], TPH	Standard Suite[a], TPH	

Note:
[a] = Standard Suite includes VOCs, SVOCs, metals, cyanide, and pesticide/PCBs.

10.5.2 Nature and Extent of Soil Contamination

Soil analytical results for organics are in Table 10.5.2, and results for inorganics are in Table 10.5.3. Appendix D is a complete analytical report for Zone C, and Appendix H contains detection only summary tables.

Table 10.5.2
AOC 523 — Former Gas Station
Organic Compound Analytical Results for Soil

Compound	Sample Interval	Frequency of Detection	Range of Detection	Mean	RBC[a]	Number of Samples Exceeding RBC
Semivolatile Organic Compounds (μg/kg) (Upper Interval — 2 Samples/Lower Interval — 2 Samples, 1 Duplicate)						
Benzo(a)anthracene	Upper	½	130.0	NA	880[b]	0
Benzo(g,h,i)perylene	Upper	½	43.0	NA	230,000	0
Benzo(k)fluoranthene	Upper	½	240.0	NA	8,800[b]	0
Chrysene	Upper	½	130	NA	8,800[b]	0
Di-n-butylphthalate	Lower	½	50.0	NA	78,000	0
Fluoranthene	Upper	2/2	61.0 - 180.0	120.5	310,000	0
Indeno(1,2,3-cd)pyrene	Upper	½	48.0	NA	880[b]	0
Phenanthrene	Upper	½	83.0	NA	230,000	0
Pyrene	Upper	2/2	52.0 - 170.0	111.0	230,000	0
BEQ	Upper	½	20.3	NA	88	0

Table 10.5.2
AOC 523 — Former Gas Station
Organic Compound Analytical Results for Soil

Compound	Sample Interval	Frequency of Detection	Range of Detection	Mean	RBC[a]	Number of Samples Exceeding RBC
Pesticide and PCB Compounds (μg/kg) (Upper Interval — 2 Samples / Lower Interval — 2 Samples, 1 Duplicate)						
alpha-BHC	Lower	½	0.006	NA	100	0
4,4-DDD	Upper	½	4.0	NA	2,700	0
	Lower	½	0.15	NA	700	0
4,4-DDE	Upper	½	14.0	NA	1,900	0
4,4-DDT	Upper	½	22.0	NA	1,900	0
	Lower	½	0.50	NA	1,000	0
delta-BHC	Lower	½	0.07	NA	2	0
Dieldrin	Lower	½	0.10	NA	1	0
Endosulfan I	Lower	½	0.24	NA	300	0
Endosulfan II	Lower	½	0.15	NA	300	0
Endosulfan sulfate	Lower	½	0.095	NA	300	0
Endrin	Upper	½	2.7	NA	2,300	0
	Lower	½	0.57	NA	400	0
Endrin aldehyde	Upper	2/2	1.4 - 5.4	3.4	2,300	0
	Lower	½	0.10	NA	400	0
Heptachlor	Upper	½	1.3	NA	140	0
	Lower	½	0.0058	NA	60	0
Methoxychlor	Upper	½	14.0	NA	39,000	0
	Lower	½	0.565	NA	62,000	0
Other Organic Compounds						
Total Petroleum Hydrocarbons (mg/kg) (Upper Interval — 2 Samples / Lower Interval — 2 Samples, 1 Duplicate)						
Petroleum Hydrocarbons	Upper	2/2	239.0 - 321.0	280.0	100	2
	Lower	2/2	63.9 - 107.0	85.45	NA	0

Table 10.5.2
AOC 523 — Former Gas Station
Organic Compound Analytical Results for Soil

Compound	Sample Interval	Frequency of Detection	Range of Detection	Mean	RBC[a]	Number of Samples Exceeding RBC
Dioxins (ng/kg) (Lower Interval — 1 Duplicate Sample Only)						
1234678-HpCDD	1/1	Lower	1.73	NA	NA	NA
1234678-HpCDF	1/1	Lower	3.59	NA	NA	NA
123678-HxCDF	1/1	Lower	0.54	NA	NA	NA
123789-HxCDF	1/1	Lower	0.64	NA	NA	NA
OCDD	1/1	Lower	12.07	NA	NA	NA
OCDF	1/1	Lower	8.57	NA	NA	NA
TCDD TEQ	1/1	Lower	19.2	NA	1,000	0

Notes:
[a] = Noncarcinogenic RBCs were adjusted to equal a hazard quotient of 0.1.
[b] = These compounds are cPAHs and were multiplied by the appropriate BEF for comparison as BEQs.
All results are in micrograms per kilogram (μg/kg) except for TPH which is in milligrams per kilogram (mg/kg) and dioxins which are in nanograms per kilogram (ng/kg).

Table 10.5.3
AOC 523 — Former Gas Station
Inorganic Analytical Results for Soil

Analyte	Sample Interval	Frequency of Detection[a]	Range of Detection (mg/kg)	Mean (mg/kg)	Reference Conc. (mg/kg)	Number of Samples Exceeding Reference
Aluminum	Upper	2/2	4,760 - 4,910	4,835.00	9,990	0
	Lower	2/2	1,300 - 6,150	3,725.00	23,700	0
Antimony	Upper	½	0.46	NA	0.55	0
Arsenic	Upper	2/2	2.7 - 6.3	4.50	14.2	2
Barium	Upper	2/2	21.2 - 34.7	27.95	77.2	0
	Lower	2/2	11.6 - 16.8	14.20	68.5	0
Calcium	Upper	2/2	2,450 - 3,850	3,150.00	NA	0
	Lower	2/2	346.5 - 419.0	382.75	NA	0
Chromium	Upper	½	5.0 - 59.2	32.10	26.4	1
	Lower	2/2	3.8 - 4.2	4.00	12.5	0
Cobalt	Upper	2/2	0.88 - 1.1	0.99	3.22	0
	Lower	2/2	0.325 - 0.710	0.52	7.1	0

Table 10.5.3
AOC 523 — Former Gas Station
Inorganic Analytical Results for Soil

Analyte	Sample Interval	Frequency of Detection[a]	Range of Detection (mg/kg)	Mean (mg/kg)	Reference Conc. (mg/kg)	Number of Samples Exceeding Reference
Copper	Upper	2/2	9.8 - 33.2	21.50	34.1	0
	Lower	2/2	1.2 - 1.4	1.30	42.2	0
Iron	**Upper**	**2/2**	**2,570 - 3,520**	**3,045.00**	**NA**	**0**
	Lower	**2/2**	**1,135 - 1,220**	**1,177.50**	**NA**	**0**
Lead	Upper	2/2	47.8 - 64.8	56.30	330	0
	Lower	2/2	3.9 - 18.55	11.23	73.2	0
Magnesium	**Upper**	**2/2**	**262 - 1,460**	**861.00**	**NA**	**0**
	Lower	**2/2**	**156 - 213**	**184.25**	**NA**	**0**
Manganese	Upper	2/2	24.5 - 34.4	29.45	92.5	0
	Lower	2/2	6.3 - 11.9	9.10	106	0
Mercury	**Upper**	**½**	**0.25**	**NA**	**0.24**	**1**
Nickel	Upper	2/2	3.1 - 6.0	4.55	12.3	0
	Lower	½	2.4	NA	16.7	0
Potassium	**Upper**	**2/2**	**130 - 235**	**182.50**	**NA**	**0**
	Lower	**2/2**	**78.5 - 137.0**	**107.75**	**NA**	**0**
Tin	Upper	2/2	1.6 - 2.3	1.95	2.95	0
	Lower	2/2	1.40 - 1.45	1.43	2.37	0
Vanadium	**Upper**	**2/2**	**4.7 - 8.1**	**6.40**	**23.4**	**0**
	Lower	**2/2**	**2.25 - 3.0**	**2.63**	**56.9**	**0**
Zinc	Upper	2/2	23.2 - 115.0	69.10	159	0
	Lower	2/2	4.75 - 5.50	5.13	243	0
Hexavalent Chromium	**Lower**	1/1	**0.261**	**NA**	**390**	**0**

Volatile Organic Compounds in Soil

No VOCs were detected in soil samples.

Semivolatile Organic Compounds in Soil

Nine SVOCs were detected in soil samples from AOC 523. Of the eight SVOCs detected in the upper interval samples, all but two were from location 523SB001. One additional SVOC was detected in the lower interval and was below its SSL. No SVOC exceeded its RBC. Only one sample contained cPAHs. The BEQ was calculated as 20.33 μg/kg, which is below the RBC for BaP of 88.0 μg/kg.

Pesticides and PCBs in Soil

Thirteen pesticide compounds were detected in soil samples from AOC 523. Seven were detected in the upper interval and 12 were detected in the lower interval. All pesticides were below their respective RBCs or SSLs.

No PCBs were detected in the soil samples collected at AOC 523.

Other Organic Compounds in Soil

Other organic compounds include the Appendix IX compound groups that are not part of the standard analytical suite, including herbicides, organophosphorous pesticides, and dioxins.

Petroleum hydrocarbons were detected in all four soil samples. Concentrations in the upper interval ranged from 239.0 mg/kg to 321.0 mg/kg exceeding the screening level of 100 mg/kg. Concentrations in the lower interval ranged from 63.9 mg/kg to 107.0 mg/kg.

No herbicides were detected in soil samples from AOC 523. No organophosphorous pesticides were detected in soil samples from AOC 523. Dioxins were detected in the duplicate sample analyzed (523CB00202). The TEQ sum for that sample was 19.2 ng/kg μg/kg, below the TCDD RBC of 1,000 ng/kg.

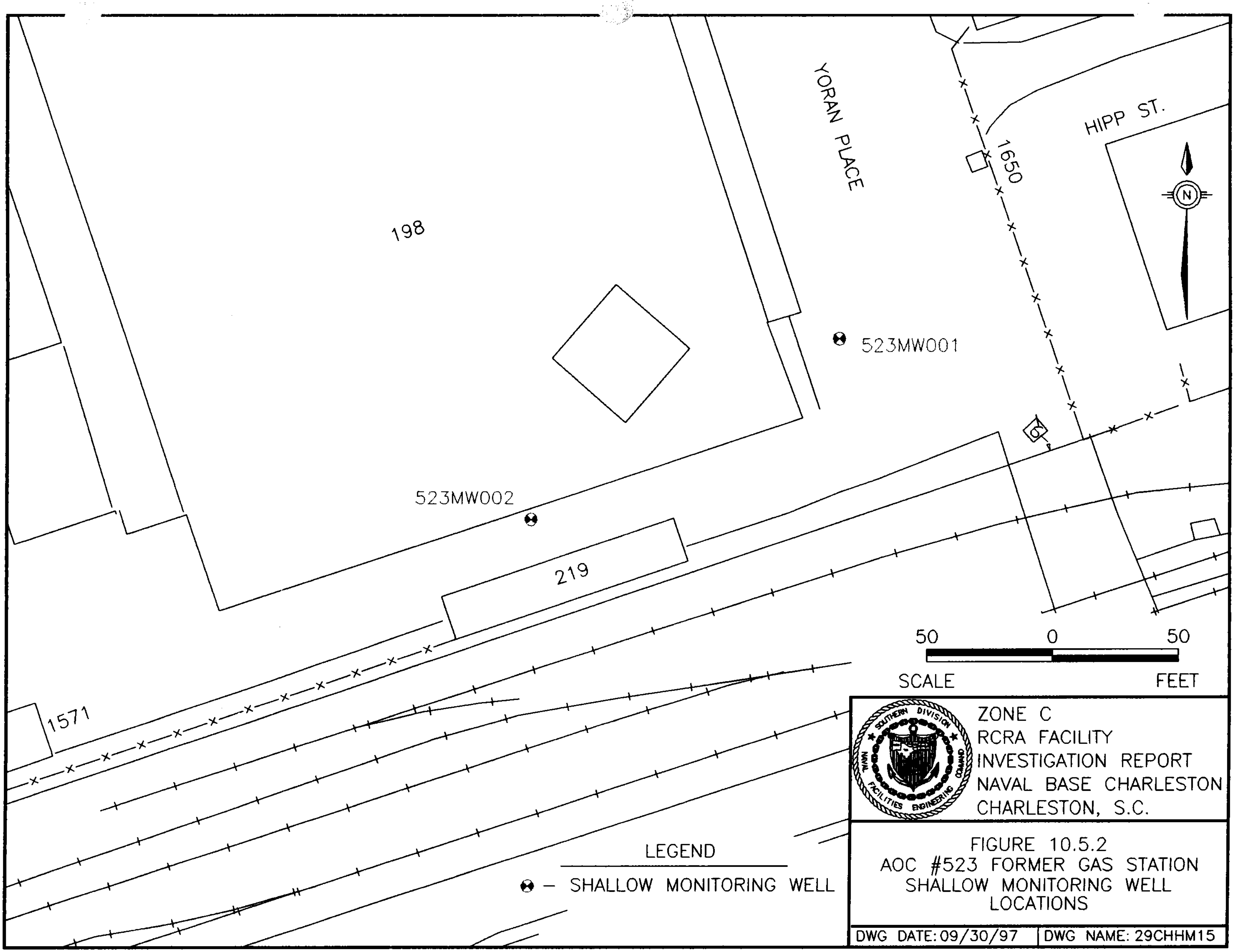
Inorganic Elements in Soil

Eighteen inorganic analytes were detected in soil samples from AOC 523. Two analytes, chromium and mercury, exceeded their reference concentrations. Table 10.5.3 summarizes the soil inorganic results for AOC 523. No cyanide was detected in soil samples from AOC 523.

Hexavalent chromium was detected at 0.261 mg/kg in duplicate sample 523SB00202. This concentration is below the RBC of 390 mg/kg for hexavalent chromium.

10.5.3 Groundwater Sampling and Analysis

Two monitoring wells were installed to identify impacts to groundwater at AOC 523 (Figure 10.5.2). Groundwater was sampled in accordance with the *Final Zone C Work Plan,* (E/A&H November 1995) and as outlined in Section 3 of this report. Groundwater samples were submitted for analyses of VOCs, SVOCs, pesticides/PCBs, metals, and TPH (GRO/DRO) or TPH (IR-418.1) at DQO Level III. One duplicate groundwater sample was submitted for TPH-DRO and Appendix IX analyses at DQO Level IV which includes the parameters listed above as well as herbicides, hexavalent chromium, organophosphorous pesticides, and dioxins. Detected concentrations in groundwater will be further evaluated based on additional groundwater data collected during the subsequent three quarters of sampling. The data are discussed in the Section 11. Sampling and analysis of groundwater for the initial round are summarized in Table 10.5.4.



ZONE C
RCRA FACILITY
INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 10.5.2
AOC #523 FORMER GAS STATION
SHALLOW MONITORING WELL
LOCATIONS

DWG DATE: 09/30/97 | DWG NAME: 29CHHM15

Table 10.5.4
AOC 523 — Former Gas Station
Groundwater Sampling and Analysis

Interval	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
Shallow	2	2	Standard Suite[a], TPH	Standard Suite[a], TPH	None

Note:
[a] = Standard Suite includes VOCs, SVOCs, metals, cyanide, and pesticides/PCBs.

10.5.4 Nature and Extent of Groundwater Contamination

Groundwater analytical results for organics are in Table 10.5.5, and for inorganics in Table 10.5.6. Appendix D is complete report of the analytical data for Zone C including groundwater results for AOC 523. Appendix H contains detection only summary tables.

Table 10.5.5
AOC 523 — Former Gas Station
Organic Compound Analytical Results for Groundwater

Compound	Frequency of Detection	Range of Detection	Tap Water RBC[a]	Number Samples Exceeding RBCs
Organophosphorous Pesticides Compounds (μg/L) (One Duplicate Sample)				
Sulfotepp	1/1	0.15	18	0
TPH Results (mg/L) (Two Samples)				
TPH (GRO)	1/2	12.12	NA	NA
Dioxins (pg/L) (One Duplicate Sample)				
OCDD	1/1	12.675	NA	NA
1234678-HpCDD	1/1	2.33	NA	NA
123789-HXCDF	1/1	3.789	NA	NA

Table 10.5.5
AOC 523 — Former Gas Station
Organic Compound Analytical Results for Groundwater

Compound	Frequency of Detection	Range of Detection	Tap Water RBC[a]	Number Samples Exceeding RBCs
1234678-HpCDF	1/1	1.351	NA	NA
OCDF	1/1	1.515	NA	NA

Note:
[a] = Noncarcinogenic RBCs were adjusted to equate to a hazard quotient of 0.1.

Table 10.5.6
AOC 523 — Former Gas Station
Inorganic Analytical Results for Groundwater

Analyte	Frequency of Detection	Range of Detection (μg/L)	Mean (μg/L)	Background Reference Conc.[a] (μg/L)	Number of Samples Exceeding Background
Aluminum	½	3,870	NA	410	1
Arsenic	2/2	15.75 - 26.60	21.15	6.07	2
Barium	½	47.85	NA	16.7	1
Calcium	2/2	17,750 - 30,300	24,025.00	NA	NA
Chromium	2/2	1.1 - 7.6	4.35	1.99	1
Cobalt	2/2	3.7 - 14.1	8.90	1.33	2
Copper	½	5.05	NA	1.90	1
Iron	2/2	9,730 - 21,000	15,365.00	NA	NA
Lead	½	8.0	NA	3.27	1
Magnesium	2/2	4,330 - 4,450	4,390.00	NA	NA
Manganese	2/2	240 - 923	581.00	608.0	1
Nickel	½	5.4	NA	3.59	1
Potassium	2/2	1,760 - 2,205	1,982.50	NA	NA
Sodium	½	10,650	NA	NA	NA
Tin	½	8.0	NA	ND	1
Vanadium	2/2	1.7 - 10.2	5.95	1.96	1
Zinc	2/2	28.6 - 65.9	47.25	13.20	2

Notes:
NA = not applicable
ND = not detected

Volatile Organic Compounds in Groundwater

No VOCs were detected in groundwater samples collected at AOC 523.

Semivolatile Organic Compounds in Groundwater

No SVOCs were detected in groundwater samples collected at AOC 523.

Pesticides and PCBs in Groundwater

No pesticides or PCBs were detected in groundwater samples collected at AOC 523.

Other Organics in Groundwater

Other organic compounds includes the Appendix IX compound groups that are not part of the standard analytical suite, including herbicides, organophosphorous pesticides, and dioxins.

TPH (IR-418.1) was detected in the sample collected from 523MW002 at 12.12 mg/L. There is no RBC for TPH (IR-418.1).

The organophosphorous pesticide sulfotepp was detected in one groundwater sample below its RBC of 18 μg/L.

Herbicides and TPH (DRO) were not detected in groundwater samples from AOC 523.

Inorganic Elements in Groundwater

Seventeen inorganic analytes were detected in groundwater samples from AOC 523. Eight analytes (aluminum, arsenic, barium, chromium, manganese, nickel, vanadium, and zinc) were above their reference concentrations. Table 10.5.6 summarizes the inorganic analytical results for groundwater at AOC 523.

10.5.5 Fate and Transport Assessment

AOC 523, a former gas station (M-1234), is currently the site of Building 198. Potential migration pathways for AOC 523 include soil-to-groundwater, groundwater-to-surface water, and emission of volatile organic compounds from surface soil to air. Environmental media sampled from this area include surface soil, subsurface soil and groundwater.

10.5.5.1 Soil-to-Groundwater Cross-Media Transport

Table 10.5.7 compares maximum detected concentrations of chemicals in AOC 523 soil and groundwater to groundwater protection SSLs, tap water RBCs, or background reference concentrations. Chromium was detected in AOC 523 surface soil above its background reference concentration and in subsurface soil below its background reference concentration. Consequently, impacts related to chromium leaching from soil to the shallow aquifer are not expected. TPH was detected in AOC 523 surface and subsurface soil but could not be quantitatively evaluated regarding soil-to-groundwater migration. TPH was also detected in AOC 523 shallow groundwater. These findings indicate TPH migration from soil to groundwater; however, TPH concentration in groundwater could not be evaluated with respect to human health endpoints.

10.5.5.2 Groundwater-to-Surface Water Cross-Media Transport

Manganese was detected in one of two monitoring wells at a concentration of 923 μg/L, which is above the its background reference concentration of 557 μg/L. It is not uncommon for manganese groundwater concentrations to occur naturally at this level in estuarine settings. Based on the tendency for manganese to adsorb to the soil matrix, migration to surface water is not expected.

10.5.5.3 Soil-to-Air Cross Media Transport

No volatile organic compound was detected in AOC 523 surface soil. As a result, the soil-to-air migration pathway is insignificant at this site.

Table 10.5.7
Chemicals Detected in Surface Soil, Subsurface Soil and Groundwater
Comparison to Groundwater Protection SSLs, Tap Water RBCs and Background UTLs
NAVBASE-Charleston, Zone C, AOC 523
Charleston, South Carolina

Parameter	Surface Soil Maximum Conc.	Subsurface Soil Maximum Conc.	Ground Water Protection SSL or UTL *	Soil Units	Ground-water Maximum Conc.	Tap Water RBC or UTL *	Water Units	Soil Conc. Exceeds SSL or UTL	Ground-water Conc. Exceeds RBC or UTL
Aluminum	4910	6150	23700	MG/KG	ND	3700	UG/L	NO	NO
Antimony	0.46	ND	0.55	MG/KG	ND	1.5	UG/L	NO	NO
Arsenic	6.3	ND	29	MG/KG	ND	15	UG/L	NO	NO
Barium	34.7	16.8	1600	MG/KG	ND	260	UG/L	NO	NO
Benzo(ghi)perylene	43	ND	46000	UG/KG	ND	150	UG/L	NO	NO
Benzo(a)pyrene Equivalents									
Benzo(a)anthracene	130	ND	2000	UG/KG	ND	0.092	UG/L	NO	NO
Benzo(k)fluoranthene	240	ND	4900	UG/KG	ND	0.92	UG/L	NO	NO
Chrysene	130	ND	160000	UG/KG	ND	9.2	UG/L	NO	NO
Indeno(1,2,3-cd)pyrene	48	ND	14000	UG/KG	ND	0.092	UG/L	NO	NO
alpha-BHC	ND	0.006	0.5	UG/KG	ND	0.011	UG/L	NO	NO
delta-BHC	ND	0.07	3	UG/KG	ND	0.052	UG/L	NO	NO
Chromium	59.2	4.2	38	MG/KG	ND	18	UG/L	YES	NO
Chromium (hexavalent)	ND	0.261	38	MG/KG	ND	18	UG/L	NO	NO
Cobalt	1.1	0.71	7.1	MG/KG	ND	220	UG/L	NO	NO
Copper	33.2	1.4	42.2	MG/KG	5.05	150	UG/L	NO	NO
4,4'-DDD	4	0.15	16000	UG/KG	ND	0.28	UG/L	NO	NO
4,4'-DDE	14	ND	54000	UG/KG	ND	0.2	UG/L	NO	NO
4,4'-DDT	22	0.5	32000	UG/KG	ND	0.2	UG/L	NO	NO
Di-n-butylphthalate	ND	50	2300000	UG/KG	ND	370	UG/L	NO	NO
Dieldrin	ND	0.1	4	UG/KG	ND	0.0042	UG/L	NO	NO
Dioxin (TCDD TEQ)	ND	0.186	4000	PG/G	ND	0.5	PG/L	NO	NO
Endosulfan	ND	0.29	1800	UG/KG	ND	22	UG/L	NO	NO
Endrin	2.7	0.575	1000	UG/KG	ND	1.1	UG/L	NO	NO
Endrin aldehyde	5.4	0.1	1000	UG/KG	ND	1.1	UG/L	NO	NO
Fluoranthene	180	ND	430000	UG/KG	ND	150	UG/L	NO	NO
Heptachlor	1.3	0.058	23000	UG/KG	ND	0.0023	UG/L	NO	NO
Lead	64.8	18.55	330	MG/KG	8	15	UG/L	NO	NO
Manganese	34.4	11.9	106	MG/KG	923	557	UG/L	NO	YES
Mercury	0.25	ND	0.3	MG/KG	ND	1.1	UG/L	NO	NO
Methoxychlor	14	0.565	160000	UG/KG	ND	18	UG/L	NO	NO
Nickel	6	2.4	130	MG/KG	5.4	73	UG/L	NO	NO
Phenanthrene	83	ND	100000000	UG/KG	ND	150	UG/L	NO	NO
Pyrene	170	ND	420000	UG/KG	ND	110	UG/L	NO	NO
Sulfotepp	ND	ND	55	UG/KG	0.15	1.8	UG/L	NO	NO
Tin	2.3	1.45	2.95	MG/KG	8	2200	UG/L	NO	NO
Total Petroleum Hydrocarbon	321	107	NA	MG/KG	12.12	NA	UG/L	YES	YES
Vanadium	8.1	3	600	MG/KG	10.2	26	UG/L	NO	NO
Zinc	115	5.5	1200	MG/KG	65.9	1100	UG/L	NO	NO

* - See Table 6-2
NA - Not available
ND - Not detected
SSL - Groundwater protection soil screening level
UTL - Grid-based background upper tolerance limit
RBC - Tap water risk-based concentration
MG/KG - Milligram per kilogram
UG/KG - Micrograms per kilogram
UG/L - Micrograms per liter

10.5.6 Human Health Risk Assessment

10.5.6.1 Site Background and Investigative Approach

AOC 523 (including SWMU 49) was a gas station (M-1234), that operated from 1958 until 1962. Currently, the site is covered by the southeastern portion of Building 198. AOC 523 was investigated to assess soil and groundwater possibly affected by past uses.

Two soil samples were collected from the upper interval at combined AOC 523 (i.e., beneath either an asphalt parking area or Building 198). Table 10.5.8 lists the analytical methods and parameters corresponding to site samples. Two shallow monitoring wells were sampled; the shallow groundwater analytes are listed in Table 10.5.9.

10.5.6.2 COPC Identification

Soil

Screening comparisons are shown in Table 10.5.10. Chromium and TPH were identified as COPCs in surface soil. No COPCs were added to this HHRA based on the Wilcox on rank sum test. Analytical results are presented in Section 5. Soil chromium results were compared to the hexavalent chromium RBC. This method is considered highly conservative, because no species-specific analysis was performed. As a result, no means of determining whether chromium was present in its less toxic trivalent state was available.

Groundwater

As shown in Table 10.5.11, the COPC identified in shallow groundwater for this site are aluminum, arsenic, manganese, and TPH. No COPCs were added to this HHRA based on the Wilcox on rank sum test. Results are in Section 5.

Table 10.5.8
Methods Run at AOC 523
Surface Soil

Site	Location	Metal	SVOA	VOA	Cn	Hexa	Diox	Oppe	Herb	Pest	Tph	Otin	Eng
523	B001	Y	Y	Y	Y					Y	IR		
523	B002	Y	Y	Y	Y					Y	IR		

METHODS:

- Metal: TAL (Target Analyte List) Metals plus tin: Methods: 6000/7000 Series
- VOA: Volatile Organic Analysis: Method 8240
- SVOA: Semi-volatile Organic Analysis: Method 8270
- Cn: Cyanide (Soil: Method 9010, Water: Method 9012)
- Hexa: Hexavalent Chromium: Method 7195
- Diox: Dioxins
- Oppe: Organophosphate Pesticides: Method 8140
- Herb: Chlorinated Herbicides: Method 8150
- Pest: Chlorinated Pesticides: Method 8080
- Tph: Total Petroleum Hydrocarbons
- Otin: Organotin
- Eng: Engineering Parameters

KEY:

- Y: Analyzed for standard list
- D: Duplicate Analysis
- IR: Method 4181
- DR: Extraction Method 3550, GC Method 8100
- GR: Extraction Method 5030, GC Method 8015

Blank value indicates this method of analysis was not performed

Table 10.5.9
Methods Run at AOC 523
Shallow Groundwater, Sampling Round 1

Site	Location	Metal	SVOA	VOA	Cn	Hexa	Diox	Oppe	Herb	Pest	Tph	Otin	Eng
523	W001	D	D	D	D		Y	Y	Y	D	GR, DR		
523	W002	Y	Y	Y	Y					Y	GR, DR		

METHODS:

- Metal: TAL (Target Analyte List) Metals plus tin: Methods: 6000/7000 Series
- VOA: Volatile Organic Analysis: Method 8240
- SVOA: Semi-volatile Organic Analysis: Method 8270
- Cn: Cyanide (Soil: Method 9010, Water: Method 9012)
- Hexa: Hexavalent Chromium: Method 7195
- Diox: Dioxins
- Oppe: Organophosphate Pesticides: Method 8140
- Herb: Chlorinated Herbicides: Method 8150
- Pest: Chlorinated Pesticides: Method 8080
- Tph: Total Petroleum Hydrocarbons
- Otin: Organotin
- Eng: Engineering Parameters

KEY:

- Y: Analyzed for standard list
- D: Duplicate Analysis
- IR: Method 4181
- DR: Extraction Method 3550, GC Method 8100
- GR: Extraction Method 5030, GC Method 8015

Blank value indicates this method of analysis was not performed

Table 10.5.10
Summary of Chemicals Present in Site Samples, AOC 523
Surface Soil
NAVBASE - Charleston, Zone C
Charleston, South Carolina

NAME	CONC UNITS	FREQ	DETECTS Min	DETECTS Max	DETECTS Avg	SCREENING Value	SCREENING # Over	SCREENING Source	NON-DETECTS Min	NON-DETECTS Max	BACKGROUND Value	BACKGROUND # Over
Carcinogenic PAHs												
B(a)P Equiv.	UG/KG	1 - 2	20.33	20.33	20.33	88			1381.28	1381.28		
Benzo(a)anthracene	UG/KG	1 - 2	130	130	130.00	880		C	710	710		
Chrysene	UG/KG	1 - 2	130	130	130.00	88000		C	580	580		
Indeno(1,2,3-cd)pyrene	UG/KG	1 - 2	48	48	48.00	880		C	500	500		
Benzo(k)fluoranthene	UG/KG	1 - 2	240	240	240.00	8800		C	670	670		
Petroleum Hydrocarbons												
Petroleum Hydrocarbons, TPH	MG/KG	2 - 2	239	321	280.00	100						
Inorganics												
Aluminum (Al)	MG/KG	2 - 2	4760	4910	4835.00	7800		N			9990	
Antimony (Sb)	MG/KG	1 - 2	0.46	0.46	0.46	3.1		N	0.21	0.21	0.55	
Arsenic (As)	MG/KG	2 - 2	2.7	6.3	4.50	0.43	2	C			14.2	
Barium (Ba)	MG/KG	2 - 2	21.2	34.7	27.95	550		N			77.2	
Calcium (Ca)	MG/KG	2 - 2	2450	3850	3150.00	NA						
Chromium (Cr)	MG/KG	2 - 2	5	59.2	32.10	39	1	N			26.4	1
Cobalt (Co)	MG/KG	2 - 2	0.88	1.1	0.99	470		N			3.22	
Copper (Cu)	MG/KG	2 - 2	9.8	33.2	21.50	310		N			34.7	
Iron (Fe)	MG/KG	2 - 2	2570	3520	3045.00	NA		N				
Lead (Pb)	MG/KG	2 - 2	47.8	64.8	56.30	400		j			330	
Magnesium (Mg)	MG/KG	2 - 2	262	1460	861.00	NA						
Manganese (Mn)	MG/KG	2 - 2	24.5	34.4	29.45	180		N			92.5	
Mercury (Hg)	MG/KG	1 - 2	0.25	0.25	0.25	2.3		N	0.11	0.11	0.24	1
Nickel (Ni)	MG/KG	2 - 2	3.1	6	4.55	160		N			12.3	
Potassium (K)	MG/KG	2 - 2	130	235	182.50	NA						
Tin (Sn)	MG/KG	2 - 2	1.6	2.3	1.95	4700					2.95	
Vanadium (V)	MG/KG	2 - 2	4.7	8.1	6.40	55		N			23.4	
Zinc (Zn)	MG/KG	2 - 2	23.2	115	69.10	2300		N			159	
Chlorinated Pesticides												
4,4'-DDD	UG/KG	1 - 2	4	4	4.00	2700		C	3.7	3.7		

Table 10.5.10
Summary of Chemicals Present in Site Samples, AOC 523
Surface Soil
NAVBASE - Charleston, Zone C
Charleston, South Carolina

NAME	CONC UNITS	FREQ	DETECTS Min	DETECTS Max	DETECTS Avg	SCREENING Value	SCREENING # Over	SCREENING Source	NON-DETECTS Min	NON-DETECTS Max	BACKGROUND Value	BACKGROUND # Over
4,4'-DDE	UG/KG	1 - 2	14	14	14.00	1900		C	3.7	3.7		
4,4'-DDT	UG/KG	1 - 2	22	22	22.00	1900		C	3.7	3.7		
Endrin	UG/KG	1 - 2	2.7	2.7	2.70	2300		N	2.7	2.7		
Endrin aldehyde	UG/KG	2 - 2	1.4	5.4	3.40	2300		h				
Heptachlor	UG/KG	1 - 2	1.3	1.3	1.30	140		C	1.1	1.1		
Methoxychlor	UG/KG	1 - 2	14	14	14.00	39000		N	3.7	3.7		
Semivolatile Organics												
Benzo(g,h,i)perylene	UG/KG	1 - 2	43	43	43.00	310000		f	670	670		
Fluoranthene	UG/KG	2 - 2	61	180	120.50	310000		N				
Phenanthrene	UG/KG	1 - 2	83	83	83.00	310000		f	670	670		
Pyrene	UG/KG	2 - 2	52	170	111.00	230000		N				

Notes:

- * Retained as a chemical of potential concern
- C The RBC is based on carcinogenic effects
- N The RBC is based on noncarcinogenic effects
- j Screening level is set equal to the soil action level
- h The RBC for endrin is used as a surrogate
- f The RBC for fluoranthene is used as a surrogate

Table 10.5.11
Summary of Chemicals Present in Site Samples, AOC 523
Shallow Groundwater, First Quarter
NAVBASE - Charleston, Zone C
Charleston, South Carolina

NAME	CONC UNITS	FREQ	DETECTS Min	DETECTS Max	DETECTS Avg	SCREENING Value	SCREENING # Over	Source	NON-DETECTS Min	NON-DETECTS Max	BACKGROUND Value	BACKGROUND # Over
Dioxins												
Dioxin Equiv.	PG/L	1 - 1	0.4299	0.4299	0.43	0.43						
1234678-HpCDD	PG/L	1 - 1	2.33	2.33	2.33							
1234678-HpCDF	PG/L	1 - 1	1.351	1.351	1.35							
123789-HxCDF	PG/L	1 - 1	3.789	3.789	3.79							
OCDD	PG/L	1 - 1	12.675	12.675	12.68							
OCDF	PG/L	1 - 1	1.515	1.515	1.52							
Petroleum Hydrocarbons												
TPH - Gasoline Range Organics	MG/L	1 - 2	12.12	12.12	12.12	0.1			0.5	0.5		
Inorganics												
Aluminum (Al)	UG/L	1 - 2	4040	4040	4040.00	3700	1	N	205	205	410	1
Arsenic (As)	UG/L	2 - 2	16.6	26.6	21.60	0.045	2	C			6.07	2
Barium (Ba)	UG/L	1 - 2	48.2	48.2	48.20	260		N	9.2	9.2	16.7	1
Calcium (Ca)	UG/L	2 - 2	17800	30300	24050.00	NA	2					
Chromium (Cr)	UG/L	2 - 2	1.1	7.9	4.50	18		N			1.99	1
Cobalt (Co)	UG/L	2 - 2	3.7	14.2	8.95	220		N			1.33	2
Copper (Cu)	UG/L	1 - 2	5.3	5.3	5.30	150		N	0.7	0.7	1.9	1
Iron (Fe)	UG/L	2 - 2	9730	21000	15365.00	1100	2	N				
Lead (Pb)	UG/L	1 - 2	8.1	8.1	8.10	15		j	4.5	4.5	3.27	1
Magnesium (Mg)	UG/L	2 - 2	4340	4450	4395.00	NA	2					
Manganese (Mn)	UG/L	2 - 2	240	925	582.50	84	2	N			608	1
Nickel (Ni)	UG/L	1 - 2	6.9	6.9	6.90	73		N	1.4	1.4	3.59	1
Potassium (K)	UG/L	2 - 2	1760	2250	2005.00	NA	2					
Sodium (Na)	UG/L	1 - 2	10700	10700	10700.00	NA	1		5120	5120		
Tin (Sn)	UG/L	1 - 2	8	8	8.00	2200			56.3	56.3		
Vanadium (V)	UG/L	2 - 2	1.7	10.5	6.10	26		N			1.96	1
Zinc (Zn)	UG/L	2 - 2	28.6	79.1	53.85	1100		N			13.2	2
Herbicides												
Sulfotep	UG/L	1 - 1	0.15	0.15	0.15	1.8		N				

Table 10.5.11
Summary of Chemicals Present in Site Samples, AOC 523
Shallow Groundwater, First Quarter
NAVBASE - Charleston, Zone C
Charleston, South Carolina

NAME	CONC UNITS	FREQ	DETECTS Min	DETECTS Max	Avg	SCREENING Value	SCREENING # Over	Source	NON-DETECTS Min	NON-DETECTS Max	BACKGROUND Value	BACKGROUND # Over

Notes:

- * Retained as a chemical of potential concern
- C The RBC is based on carcinogenic effects
- N The RBC is based on noncarcinogenic effects
- j Screening level is set equal to the treatment technique action level

10.5.6.3 Exposure Assessment

Exposure Setting

AOC 523 is covered by an asphalt parking lot and Building 198. Therefore, the soil exposure pathway is not currently completed. The future use of combined AOC 523 is unknown, although it is in a section of NAVBASE currently projected as a community support area.

Potentially Exposed Populations

Potentially exposed populations are current and future site workers. Additional potentially exposed populations are future site residents. Future site resident and worker exposure scenarios were addressed in this risk assessment. The hypothetical future site worker scenario assumed continuous exposure to surface soil conditions and the use of shallow groundwater as a potable water source. Current site workers' exposure would be less than that assumed for the hypothetical future site worker scenario because of their limited soil contact and because groundwater is not currently used onsite as potable or process water. Neither soil nor groundwater exposure pathways are currently completed. Therefore, future worker assessment is considered protective of current site users. The future site resident scenario was built on the premise that existing buildings would be removed and replaced with dwellings. In addition, the future site residents were assumed to use the shallow aquifer onsite as a source of drinking water.

Exposure Pathways

Exposure pathways for the site workers are dermal contact and incidental ingestion of surface soil, and ingestion of shallow groundwater through potable use. VOCs were not identified as COPCs in the shallow aquifer, and thus inhalation of volatilized groundwater contaminants was not considered a viable exposure pathway. The exposure pathways for future residential land use are the same as those for the future site worker. In addition, the hypothetical future site worker scenario assumed continuous exposure to surface soil and groundwater conditions. Uniform

exposure was assumed for all sample locations. Table 10.5.12 justifies exposure pathways 1
assessed in this HHRA. 2

Table 10.5.12
Exposure Pathways Summary — AOC 523
NAVBASE — Zone C
Charleston, South Carolina

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Current Land Uses			
Current Site Users/Maintenance	Air, Inhalation of gaseous contaminants emanating from soil	No	Based on the COPCs identified in this HHRA for AOC 523, no significant VOC concentrations were identified at this site.
	Air, Inhalation of chemicals entrained in fugitive dust	No	Exposure to dust generated by site users traversing the area would be minimized by paved, submerged, and/or vegetated soils.
	Shallow groundwater, Ingestion of contaminants during potable or general use	No (Qualified)	Shallow groundwater is not currently used as a source of potable or non-residential water at AOC 523. Future land use assessment is considered to be protective of current receptors.
	Shallow groundwater, Inhalation of volatilized shallow groundwater contaminants	No	VOCs were not detected in shallow groundwater.
	Soil, Incidental ingestion	No (Qualified)	Future land use assessment is considered to be protective of current receptors.
	Soil, Dermal contact	No (Qualified)	Future land use assessment is considered to be protective of current receptors.
Future Land Uses			
Future Site Residents (Child and Adult) and Future Site Worker	Air, Inhalation of gaseous contaminants emanating from soil	No	Based on the COPCs identified in this HHRA for AOC 523, no significant VOC concentrations were identified at this site.
	Air, Inhalation of chemicals entrained in fugitive dust	No	Exposure to dust generated by site users traversing the area would be minimized by paved and/or vegetated soils.
	Shallow groundwater, Ingestion of contaminants during potable or general use	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Shallow groundwater, Inhalation of volatilized contaminants during domestic use	No	VOCs were not detected in shallow groundwater.

Table 10.5.12
Exposure Pathways Summary — AOC 523
NAVBASE — Zone C
Charleston, South Carolina

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
	Soil, Incidental ingestion	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Soil, Dermal contact	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Wild game or domestic animals, Ingestion of tissue impacted by media contamination	No	Hunting/taking of game and/or raising livestock is prohibited within the Charleston, South Carolina, city limits.
	Fruits and vegetables, Ingestion of plant tissues grown in media	No	The potential for significant exposure via this pathway is low relative to that of other exposure pathways assessed.

Exposure Point Concentrations

As discussed in Section 7 of this HHRA, UCLs were calculated for datasets consisting of at least 10 samples. Only two surface soil samples delineate combined AOC 523; therefore, the maximum concentrations reported for chromium and TPH were used as EPCs to estimate exposure. Of the two soil samples collected, chromium and TPH were reported in both samples. FI/FCs were not applied to exposure estimates for combined AOC 523.

Only two shallow monitoring wells were installed onsite. Therefore, the maximum reported concentration of each COPC was used to estimate exposure via the groundwater ingestion pathway.

Quantification of Exposure

Soil

CDIs for ingestion and dermal contact with surface soil are shown in Tables 10.5.13 and 10.5.14, respectively.

Table 10.5.13
Chronic Daily Intakes (CDI)
Incidental Ingestion of Surface Soil (0-1')
AOC 523 and SWMU 49 Zone C
Naval Base Charleston
Charleston, SC

Chemical	TEF	Fraction Ingested fro Contaminate Source	Exposure Point Concentration (mg/kg)	Potential Future Resident adult H-CDI (mg/kg-day)	Potential Future Resident child H-CDI (mg/kg-day)	Potential Futur Resident lwa C-CDI (mg/kg-day)	Potential Curren Worker adult H-CDI (mg/kg-day)	Potential Current Worker adult C-CDI (mg/kg-day)
Chromium	NA	1	59.2	8.11E-05	7.57E-04	9.27E-05	2.90E-05	1.03E-05

NOTES:

TEF toxic equivalency factor relative to Benzo(a)pyrene
lwa lifetime weighted average; used to calculate carcinogenic CDI, RAGS Parts A and B
CDI Chronic Daily Intake in mg/kg-day
H-CDI CDI for hazard quotient
C-CDI CDI for excess cancer risk
* Reflects the estimated fraction of the site impacted by the corresponding COPC.

Table 10.5.14
Chronic Daily Intakes (CDI)
Dermal Contact with Surface Soil (0-1')
AOC 523 and SWMU 49 Zone C
Naval Base Charleston
Charleston, SC

Chemical -	TEF	Adjusted Exposure Point Concentration (mg/kg)	Fraction Contacted fro Contaminated Source *	Dermal Absorption Factor (unitless)	Potential Future Resident adult H-CDI (mg/kg-day)	Potential Future Resident child H-CDI (mg/kg-day)	Potential Futur Resident lwa C-CDI (mg/kg-day)	Potential Curren Worker adult H-CDI (mg/kg-day)	Potential Current Worker adult C-CDI (mg/kg-day)
Chromium	NA	59.2	1	0.001	3.32E-06	1.10E-05	2.08E-06	2.37E-06	8.48E-07

NOTES:

TEF Toxic Equivalency Factor relative to Benzo(a)pyrene
CDI Chronic Daily Intake in mg/kg-day
H-CDI CDI for hazard quotient
C-CDI CDI for excess cancer risk
\- The dermal absorption factor was applied to the exposure point concentration to reflect the different trans-dermal migration of inorganic versus organic chemicals
* Reflects the estimated fraction of the site impacted by the corresponding COPC.

Groundwater

The CDIs for groundwater ingestion are presented in Table 10.5.15.

10.5.6.4 Toxicity Assessment

Toxicity assessment terms and methods are discussed in Section 7 of this report. In the following paragraphs, each COPC identified at AOC 523 is profiled and discussed. Table 10.5.16 presents toxicological information used to quantify risk and hazard associated with soil and groundwater COPCs.

Aluminum is one of the most abundant metals in the earth's crust (7% aluminum), and it is ubiquitous in air and water, as well as soil. This metal is water-soluble, silvery, and ductile, suggesting its usefulness in many processes. Ingesting aluminum can affect the absorption of other elements within the gastrointestinal tract and can alter intestinal function. Aluminum potentially interferes with the absorption of essential nutrients and cholesterol. Another effect on the gastrointestinal system is the inhibition of acetylcholine-induced contractions, which are part of the neuro-muscular system controlling bowel muscles. The effect could explain why aluminum-containing antacids often produce constipation. Aluminum dust is moderately flammable and explosive in heat. Inhaling this dust can cause fibrosis (aluminosis) (Klaassen et al. 1986; Dreisbach et al. 1987). No data are available on an applicable SF or the USEPA cancer group. The USEPA Region IV Office of Health Assessment suggested using the provisional oral RfD of 1.0 mg/kg-day. The aesthetic-based SMCL for drinking water is 50 to 200 μg/L (USEPA, Office of Water).

Arsenic exposure via the ingestion route causes darkening and hardening of the skin in chronically exposed humans. Inhalation exposure to arsenic causes neurological deficits, anemia, and cardiovascular effects (Klaassen, et al., 1986). USEPA set 0.3 μg/kg-day as the RfD for arsenic based on an NOAEL of 0.8 μg/kg-day in a human exposure study. Arsenic's effects on the

Table 10.5.15
Chronic Daily Intakes (CDI)
Ingestion/Inhalation of COPCs in Shallow Groundwater
AOC 523 and SWMU 49 Zone C
Naval Base Charleston
Charleston, SC

Chemical	Adjusted Exposure Point Concentration (mg/liter)	Potential Future Resident adult H-CDI (mg/kg-day)	Potential Future Resident child H-CDI (mg/kg-day)	Potential Futur Resident lwa C-CDI (mg/kg-day)	Potential Future Worker adult H-CDI (mg/kg-day)	Potential Future Worker adult C-CDI (mg/kg-day)
Aluminum	3.87	1.06E-01	2.47E-01	5.83E-02	3.79E-02	1.86E-02
Arsenic	0.027	7.29E-04	1.70E-03	4.01E-04	2.60E-04	1.28E-04
Manganese	0.923	2.53E-02	5.90E-02	1.39E-02	9.03E-03	4.44E-03

NOTES:

lwa lifetime weighted average
CDI Chronic Daily Intake
H-CDI Non-carcinogenic hazard based Chronic Daily Intake
C-CDI Carcinogenic risk based Chronic Daily Intake

Table 10.5.16
Toxicological Database Informatio
for Chemicals of Potential Concer
AOC 523
NAVBASE Charleston, Zone C

Non-Carcinogenic Toxicity Data

Chemical	Oral Reference Dose (mg/kg/day)		Confidence Level	Critical Effect	Uncertainty Factor Oral	Inhalation Reference Dose (mg/kg/day)		Confidence Level	Critical Effect	Uncertainty Factor Inhalation
Aluminum	1	e			ND	ND				ND
Arsenic	0.0003	a	M	hyperpigmentation	3	ND				ND
Chromium	0.005	a	L	NA	500/1	ND				ND
Manganese (food)	0.047	a	NA	neurological effects	1	ND				ND
Manganese (water)	0.023	a	NA	neurological effects	1	1.43E-05	a	M	neurological effects	1000

NOTES:

a Integrated Risk Information System (IRIS)
b Health Effects Assessment Summary Tables (HEAST)
c HEAST alternative method
d USEPA Region III Screening Tables
e EPA Environmental Criteria and Assessment Office - Cincinnati (provisional)
f Withdrawn from IRIS or HEAST
NA Not applicable or not available
ND Not determined due to lack of information

Table 10.5.16
Toxicological Database Informatio
for Chemicals of Potential Concer
AOC 523
NAVBASE Charleston, Zone C

Carcinogenic Toxicity Data

Chemical	Oral Slope Factor [(mg/kg/day)]-1		Inhalation Slope Factor [(mg/kg/day)]-1		Weight of Evidence	Tumor Type
Aluminum	ND		ND		ND	
Arsenic	1.5	a	15.1	a	A	various
Chromium	ND		42	a	D	
Manganese (food)	ND		ND		D	
Manganese (water)	ND		ND		D	

nervous and cardiovascular systems are primarily associated with acute exposure to higher concentrations. Exposure to arsenic-containing materials caused cancer in humans. Inhalation of these materials can lead to increased lung cancer risk, and ingestion of these materials is associated with increased skin cancer rates. Arsenic has been classified as a group A carcinogen by USEPA, which set the 1.5 $(mg/kg\text{-}day)^{-1}$ SF for arsenic. As listed in IRIS (search date September 1, 1995), the classification is based on sufficient evidence from human data. An increased lung cancer mortality was observed in multiple human populations exposed primarily through inhalation. Also, increased mortality from multiple internal organ cancers (liver, kidney, lung, and bladder) and an increased incidence of skin cancer were observed in populations consuming drinking water high in inorganic arsenic. Human milk contains about 3 μg/L arsenic. The RBC for arsenic in tap water is 0.038 μg/L. As listed in IRIS (search date September 1, 1995), the critical effect of this chemical is hyperpigmentation, keratosis, and possible vascular complications. The uncertainty factor was determined to be 3 and the modifying factor was determined to be 1.

Chromium exists in two stable, natural forms: trivalent (CrIII), and hexavalent (CrVI). Acute exposure to chromium can result in kidney damage following oral exposure or damage to the nasal mucosa and septum following inhalation exposure. Chronic inhalation exposure to hexavalent chromium has resulted in kidney and respiratory tract damage, as well as excess lung cancer in both animals and humans following occupational exposure. Only hexavalent chromium is believed to be carcinogenic by inhalation (Gradient, 1991). Oral RfD values for both forms of chromium are 1.0 and 5E-3 (mg/kg-day). For trivalent chromium, the RfD is based on liver toxicity in the rat. For the hexavalent form, the RfD is based on unspecified pathological changes observed in rat studies. In addition, hexavalent chromium is considered a group A carcinogen for inhalation exposures, and a SFo of 42 $(mg/kg\text{-}day)^{-1}$ has been established for the hexavalent form. Vitamin supplements contain approximately 0.025 mg of chromium. As listed in IRIS (search date June 28, 1995), no critical effects were observed for chromium (III). The uncertainty factor was determined to be 100 and the modifying factor was determined to be 10. As listed in IRIS (search date June 28, 1995), no critical effects were observed for chromium (VI). The uncertainty factor was determined to be 500 and the modifying factor was determined to be 1. For this assessment, chromium was assumed to exist in the hexavalent state.

Manganese is an essential nutrient, but chronic exposure (0.8 mg/kg-day) causes mental disturbances. Studies have shown that manganese uptake from water is greater than manganese uptake from food, and the elderly appear to be more sensitive than children (Klaassen et al. 1986; Dreisbach et al. 1987). Because of the different uptake rates in water and food, USEPA set two oral RfDs – one for water and one for food. These RfDs are 0.005 and 0.14 mg/kg-day, respectively. Inhalation of manganese dust causes neurological effects and increased incidence of pneumonia. An inhalation RfD was set to 0.0000143 mg/kg-day. According to USEPA, manganese cannot be classified as to its carcinogenicity. Therefore, the cancer class for manganese is group D. As listed in IRIS (search date June 29, 1995), the basis for the classification is existing studies that are inadequate to assess the carcinogenicity of manganese. Manganese is an element considered essential to human health. The typical vitamin supplement dose of manganese is 2.5 mg/day. As listed in IRIS (search date June 29, 1995), the critical effects of this chemical in water in the oral summary are CNS effects. The uncertainty factor was determined to be 1 and the modifying factor was determined to be 1. The critical effects of this chemical in food in the oral summary are CNS effects. The uncertainty factor was 1 and the modifying factor was 1. As listed in IRIS (search date June 29, 1995), the critical effect of this chemical in the inhalation summary is impairment of neuro-behavioral function. The uncertainty factor was 1000 and the modifying factor was 1. The IRIS RfC is 0.00005 mg/m^3.

10.5.6.5 Risk Characterization

Surface Soil Pathways

Exposure to surface soil onsite was evaluated under both residential and industrial (site worker) scenarios. For these scenarios, the incidental ingestion and dermal contact exposure pathways were evaluated. For noncarcinogenic contaminants evaluated for future site residents, hazard was computed separately to address child and adult exposure. Tables 10.5.17 and 10.5.18 present the estimated carcinogenic risks and/or HQs associated with the incidental ingestion of and dermal contact with site surface soil, respectively.

Hypothetical Site Residents

ILCR was not estimated for the soil exposure pathway because chromium is not a carcinogen. For the ingestion pathway, HIs estimated for the hypothetical adult and child residents were 0.02 and 0.2, respectively. Dermal contact HIs for the adult and child residents were estimated to be 0.003 and 0.01, respectively.

Hypothetical Site Workers

ILCR was not estimated for the soil exposure pathway because chromium is not a carcinogen. For the ingestion pathway, HIs estimated for the hypothetical site worker ingestion and dermal contact exposure pathways were 0.01 and 0.002, respectively.

Combined AOC 523 is currently covered by either an asphalt parking lot or by Building 198. Currently, no soil exposure pathway is completed onsite, and site conditions would have to change significantly to allow for direct soil exposure pathways.

Groundwater Pathways

Exposure to shallow groundwater onsite was evaluated under both residential and industrial scenarios. The ingestion exposure pathway was evaluated assuming the site groundwater will be used for potable and/or domestic purposes and that an unfiltered well, drawing from the corresponding water-bearing zone, will be installed. For noncarcinogenic contaminants evaluated relative to future site residents, HIs were estimated separately for child and adult receptors. Table 10.5.19 presents the risk and hazard estimated for the groundwater exposure pathway.

Table 10.5.17
Hazard Quotients and Incremental Lifetime Cancer Risks
Incidental Surface Soil Ingestion
AOC 523 and SWMU 49 Zone C
Naval Base Charleston
Charleston, SC

Chemical	Oral RfD Used (mg/kg-day)	Oral SF Used (mg/kg-day)-1	Potential Future Resident adult Hazard Quotient	Potential Future Resident child Hazard Quotient	Potential Futur Resident lwa ILCR	Potential Curren Worker adult Hazard Quotient	Potential Current Worker adult ILCR
Chromium	0.005	NA	0.016	0.15	ND	0.0058	ND
SUM Hazard Index/ILCR			0.02	0.2	ND	0.01	ND

NOTES:

NA Not available
ND Not Determined due to lack of available information
lwa lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime excess Cancer Risk

Table 10.5.18
Hazard Quotients and Incremental Lifetime Cancer Risks
Dermal Contact With Surface Soil
AOC 523 and SWMU 49 Zone C
Naval Base Charleston
Charleston, SC

Chemical	Dermal Adjustment	Oral RfD Used (mg/kg-day	Oral SF Used (mg/kg-day)-1	Potential Future Resident adult Hazard Quotient	Potential Future Resident child Hazard Quotient	Potential Futu Resident lwa ILCR	Potential Curren Worker adult Hazard Quotient	Potential Current Worker adult ILCR
Chromium	0.2	0.001	NA	0.003	0.011	ND	0.0024	ND
SUM Hazard Index/ILCR				0.003	0.011	ND	0.002	ND

NOTES:

NA Not available
ND Not Determined due to lack of available information
lwa lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime excess Cancer Risk
\- Dermal to absorbed dose adjustment factor is applied to adjust for Oral SF and RfD (i.e., the oral RfD is based on oral absorption efficiency which should not be applied to dermal exposure and dermal CDI)

Table 10.5.19
Hazard Quotients and Incremental Lifetime Cancer Risks
Shallow Groundwater Ingestion
AOC 523 and SWMU 49 Zone C
Naval Base Charleston
Charleston, SC

Chemical	Oral RfD Used (mg/kg-day)	Oral SF Used (mg/kg-day)-1	Potential Future Resident adult Hazard Quotient	Potential Future Resident child Hazard Quotient	Potential Futur Resident lwa ILCR	Potential Future Worker adult Hazard Quotient	Potential Future Worker adult ILCR
Aluminum	1	NA	0.11	0.25	ND	0.04	ND
Arsenic	0.0003	1.5	2.4	5.7	6.0E-04	0.9	1.9E-04
Manganese	0.023	NA	1.1	2.6	ND	0.4	ND
SUM Hazard Index/ILCR			4	8	6E-04	1	2E-04

NOTES:

NA Not available
ND Not Determined due to lack of available information
lwa lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime excess Cancer Risk

Hypothetical Site Residents

The ingestion ILCR for the lifetime weighted average site resident was estimated to be 6E-4. The sole contributor to ILCR was arsenic, which did not exceed the MCL. Hazard indices for the adult and child resident were estimated to be 4 and 8, respectively, with manganese as the primary contributor.

Hypothetical Site Workers

The ingestion ILCR for the site worker was estimated to be 2E-4. The sole contributor to ILCR was arsenic, which did not exceed the MCL. The HI for the site worker was estimated to be 1. Manganese was the primary contributor to hazard.

Current Site Worker

Groundwater is not currently used as a potable water source at Zone C because municipal water is readily available. As previously mentioned, it is highly unlikely that the site will be developed as a residential area, and it is unlikely that a potable-use well would be installed onsite. It is probable that, if residences were constructed onsite and an unfiltered well was installed, the salinity and dissolved solids would preclude this aquifer from being an acceptable potable water source.

COCs Identified

COCs are identified based on cumulative (all pathways) risk and hazard projected for this site. USEPA has established a generally acceptable risk range of 1E-4 to 1E-6, and a HI threshold of 1.0 (unity). In this HHRA, a COC was considered to be any chemical contributing to a cumulative risk level of 1E-6 or one whose HQ exceeds 0.1. For carcinogens, this approach is relatively conservative, because a cumulative risk level of 1E-4 (and individual ILCR of 1E-6) is recommended by USEPA Region IV as the trigger for establishing COCs. The COC selection method presented was used to provide a more comprehensive evaluation of chemicals contributing to carcinogenic risk or noncarcinogenic hazard during the RGO development process. Table 10.5.20 presents the COCs identified as well as summary exposure pathway risk and hazard estimated for combined AOC 523.

Surface Soil

Hypothetical Site Residents (Future Land Use)

No COCs were identified for this scenario based on the sum ILCR and HI. Chromium is identified as a COC in Table 10.5.20 based solely on an HQ value of .15 and that it exists completely in the hexavalent state. Because of the inherently conservative process by which chromium was evaluated and the fact the sum HI < 1 since it was the only contributor, chromium was eliminated from further consideration.

Hypothetical Site Workers (Future Land Use)

No COCs were identified for this scenario based on the sum ILCR and HI.

No COCs were identified for the soil pathway; therefore, no discussion is warranted.

Groundwater

Hypothetical Site Residents (Future Land Use)

Arsenic, aluminum, and manganese were identified as COCs in shallow groundwater for this scenario.

Hypothetical Site Workers (Future Land Use)

Arsenic and manganese were identified as COCs in shallow groundwater for this scenario.

Table 10.5.20
Summary of Risk and Hazard-based COCs for AOC 523 and SWMU 49
NAVBASE - Charleston Zone C
Charleston, South Carolina

Medium	Exposure Pathway		Potential Futu Resident Adul Hazard Quotie	Potential Futu Resident Chil Hazard Quotie	Potential Future Resident lwa ILCR	Site Worker Hazard Quotie	Site Worker ILCR	Identification of COCs			
Surface Soil	Incidental Ingestion	Chromium	0.02	0.15	ND	0.006	ND				
	Dermal Contact	Chromium	0.003	0.011	ND	0.002	ND				
Surface Soil Pathway Sum			0.02	0.2	ND	0.008	ND				
Shallow Groundw	Ingestion	Aluminum	0.1	0.2	ND	0.04	ND	1			
		Arsenic	2.4	5.7	6.0E-04	0.9	1.9E-04	1	2	3	4
		Manganese	4	8	ND	1	ND	1		3	
Shallow GW Pathway Sum			6.5	13.9	6E-04	1.9	2E-04				
Sum of All Pathways			7	14	6E-04	2	2E-04				

Notes:
ND indicates not determined due to the lack of available risk information.
ILCR indicates incremental excess lifetime cancer risk
HI indicates hazard index
1- Chemical is a COC by virtue of projected child residence non-carcinogenic hazard.
2- Chemical is a COC by virtue of projected future resident lifetime ILCR.
3- Chemical is a COC by virtue of projected site worker non-carcinogenic hazard.
4- Chemical is a COC by virtue of projected site worker ILCR.

10.5.6.6 Risk Uncertainty

Characterization of Exposure Setting and Identification of Exposure Pathways

The potential for high bias is introduced through the exposure setting and pathway selection due to the highly conservative assumptions (i.e., future residential use) recommended by USEPA Region IV when assessing potential future and current exposure. The exposure assumptions made in the site worker scenario are highly protective and overestimate exposure. Under current site use conditions, workers are not exposed to either combined AOC 523 surface soil or groundwater. Unless Building 198 were demolished and asphalt surfaces were removed, no soil contact would be expected during noninvasive activities.

Residential use of the site would not be expected based on current site uses and the nature of surrounding buildings. Current reuse plans call for use as a community support area. If this area is used as a residential site, Building 198 would be demolished, the asphalt parking area surface removed, and surface soil conditions would likely change — soil could be covered with landscaping soil and/or a house. Consequently, exposure to current surface soil conditions would not be likely under a true future residential scenario. These factors indicate that exposure pathways assessed in this HHRA would generally overestimate the risk and hazard posed to site workers and future site residents.

Shallow groundwater is not currently used at AOC 523 for potable or industrial purposes. A basewide system provides drinking and process water to buildings throughout Zone C. This system is scheduled to remain in operation under the current base reuse plan. As a result, shallow groundwater would not be expected to be used under future site use scenarios. Therefore, the scenario established to project risk/hazard associated with shallow groundwater exposure is highly conservative, and associated pathways are not expected to be completed in the future.

Determination of Exposure Point Concentrations

The maximum concentration reported for chromium was used as the EPC for surface soil. The maximum concentrations reported for groundwater COPCs were used as the EPCs for shallow groundwater. As a result, the quantification of exposure does not account for potential variability in the contaminant concentrations in groundwater, and exposure has been overestimated.

Frequency of Detection and Spatial Distribution

The use of the maximum concentration as an EPC is questionable for the COC at this site, and the calculated risk and hazard could be skewed up or down because of the low frequency of detection. The biased sampling approach would tend to skew exposure estimates high.

Quantification of Risk/Hazard

As indicated by the discussions above, the uncertainty inherent in the risk assessment process is great. In addition, many site-specific factors affecting the uncertainty of this assessment would upwardly bias the risk and hazard estimates. Exposure pathway-specific sources of uncertainty are discussed below.

Soil

Except for arsenic and manganese, no CPSS screened and eliminated from formal assessment because it did not exceed the corresponding RBC was reported at a concentration within 10% of its RBC. This minimizes the likelihood of potentially significant cumulative risk/hazard based on the eliminated CPSSs. Arsenic and manganese exceeded the corresponding RBCs and were eliminated as COPCs based on comparisons to reference concentrations.

Because the future land use of AOC 523 is unknown, both the worker and residential exposure scenarios were assessed in this HHRA. As previously discussed, these scenarios would likely lead to overestimates of risk and/or hazard, especially under RME assumptions. An individual map was not produced for this site.

The CT assumption for residential exposure duration is nine years compared to the 30-year assumption for RME. Changing only this exposure assumption would result in a 66.7% reduction in projected ILCR. If all other exposure assumptions remain fixed, application of the CT exposure duration would result in risk projections below the USEPA acceptable risk threshold of 1E-6.

Groundwater

Groundwater is not currently used as a potable water source at Zone C because municipal water is readily available. As previously mentioned, it is highly unlikely that the site will be developed as a residential area, and it is unlikely that a potable-use well would be installed onsite. It is probable that, if residences were constructed onsite and an unfiltered well were installed, the salinity and dissolved solids would preclude this aquifer from being an acceptable potable water source. No COPCs were added to this HHRA based on the Wilcox on rank sum test. Results are in Section 5.

Aluminum and manganese concentrations varied around their respective reference concentrations in second, third, and fourth-quarter samples from 523-G-W001 only. Arsenic levels declined over time in both wells and were non-detect in the fourth quarter. These trends suggest that use of first-quarter results to estimate exposure likely led to an overestimate of risk/hazard.

10.5.6.7 Risk Summary

The risk and hazard posed by contaminants at combined AOC 523 were assessed for the hypothetical RME site worker and the hypothetical RME future site resident. In surface soil, the incidental ingestion and dermal contact pathways were assessed in this HHRA. Ingestion was the sole pathway evaluated relative to shallow groundwater. Table 10.5.21 summarizes risk for each pathway/receptor group evaluated for combined AOC 523.

10.5.6.8 Remedial Goal Options

Soil

No COCs were identified for the soil exposure pathway; therefore, no RGOs were warranted.

Groundwater

RGOs for the hypothetical site residential and site worker scenarios were calculated for COCs as shown in Tables 10.5.22 and 10.5.23, respectively. Inclusion in an RGO table does not necessarily indicate that remedial action is warranted. RGOs are options to be considered when making risk management decisions which, in accordance with RAGS, are not to be included in HHRAs. The maximum detected arsenic concentration (27μg/l) did not exceed its MCL.

10.5.7 Corrective Measures Considerations

No COCs were identified for soil; therefore, corrective measures are not required for these media. Aluminum, arsenic, and manganese were detected in shallow groundwater. Aluminum, arsenic, and manganese concentrations detected were below background concentrations for other zones. Table 10.5.24 present potential corrective measures for consideration. Additional quarterly groundwater data are evaluated in Section 11 where the final recommendation for the site will be made.

Table 10.5.21
Summary of Risk and Hazard for AOC 523 and SWMU 49
NAVBASE - Charleston Zone C
Charleston, South Carolina

Medium	Exposure Pathway	HI (Adult)	HI (Child)	ILCR (LWA)	HI (Worker)	ILCR (Worker)
Surface Soil	Incidental Ingestion	0.02	0.2	ND	0.01	ND
	Dermal Contact	0.003	0.01	ND	0.002	ND
Shallow Groundwater	Ingestion	8	18	6.0E-04	2.7	1.9E-04
Sum of All Pathways		8	18	6E-04	3	2E-04

Notes:
ND indicates not determined due to the lack of available risk information.
ILCR indicates incremental excess lifetime cancer risk
HI indicates hazard index
LWA indicates lifetime weighted average exposure

Table 10.5.22
Residential-Based Remedial Goal Options Shallow Groundwater
AOC 523 and SWMU 49 Zone C
Naval Base Charleston
Charleston, South Carolina

						Hazard-Based Remedial Goal Optio			**Risk-Based Remedial Goal Options**				
Chemical	Oral SF (mg/kg-day)	Inh. SF (mg/kg-day)	Oral RfD (mg/kg-day	Inh RfD (mg/kg-day	Unadj. EPC mg/l	**0.1** mg/l	**1.0** mg/l	**3** mg/l	**1E-06** mg/l	**1E-05** mg/l	**1E-04** mg/l	ARAR mg/l	Background Concentration mg/l
Aluminum	NA	NA	1	NA	3.87	1.6	15.6	46.9	ND	ND	ND	0.2	0.41
Arsenic	1.5	NA	0.0003	NA	0.027	0.0005	0.005	0.01	0.00004	0.0004	0.0044	0.05	0.0061
Manganese	NA	NA	0.023	NA	0.923	0.036	0.36	1.1	ND	ND	ND	0.05	0.608

NOTES:

EPC exposure point concentration
NA not applicable
ND not determined
- remedial goal options were based on the residential lifetime weighted average for carcinogens and the child resident for noncarcinogens

Table 10.5.23
Worker-Based Remedial Goal Options Shallow Groundwater
AOC 523 and SWMU 49 Zone C
Naval Base Charleston
Charleston, South Carolina

Chemical	Oral SF (mg/kg-day)	Inh. SF (mg/kg-day)	Oral RfD (mg/kg-day	Inh RfD (mg/kg-day	Unadj. EPC mg/l	Hazard-Based Remedial Goal Optio 0.1 mg/l	1.0 mg/l	3 mg/l	Risk-Based Remedial Goal Options 1E-06 mg/l	1E-05 mg/l	1E-04 mg/l	ARAR mg/l	Background Concentration mg/l
Arsenic	1.5	NA	0.0003	NA	0.0266	0.003	0.03	0.31	0.0001	0.001	0.014	0.05	0.0061
Manganese	NA	NA	0.023	NA	0.923	0.235	2.35	23.51	ND	ND	ND	0.05	0.608

NOTES:

EPC exposure point concentration
NA not applicable
ND not determined

Table 10.5.24
Potential Corrective Measures

Medium	Compounds	Potential Corrective Measures
Shallow Groundwater	Aluminum, arsenic, manganese	a) No action, monitoring, intrinsic remediation b) Extraction, chemical and physical treatment, discharge.

10.6 Other Sites Designated CSI (Includes AOCs 510, 512, 513, 517, 518, and 520)

AOCs 510, 512, 513, 517, 518, and 520 were all proposed for CSIs in the *Final Zone C Work Plan* (E/A&H, 1995). These group of sites had a common investigative strategy and were combined in the work plan; however, they do not have adjoining or overlapping boundaries. Each site is discussed as a subsection to 10.6.

10.6.1 AOC 510 — Geotechnical Laboratory

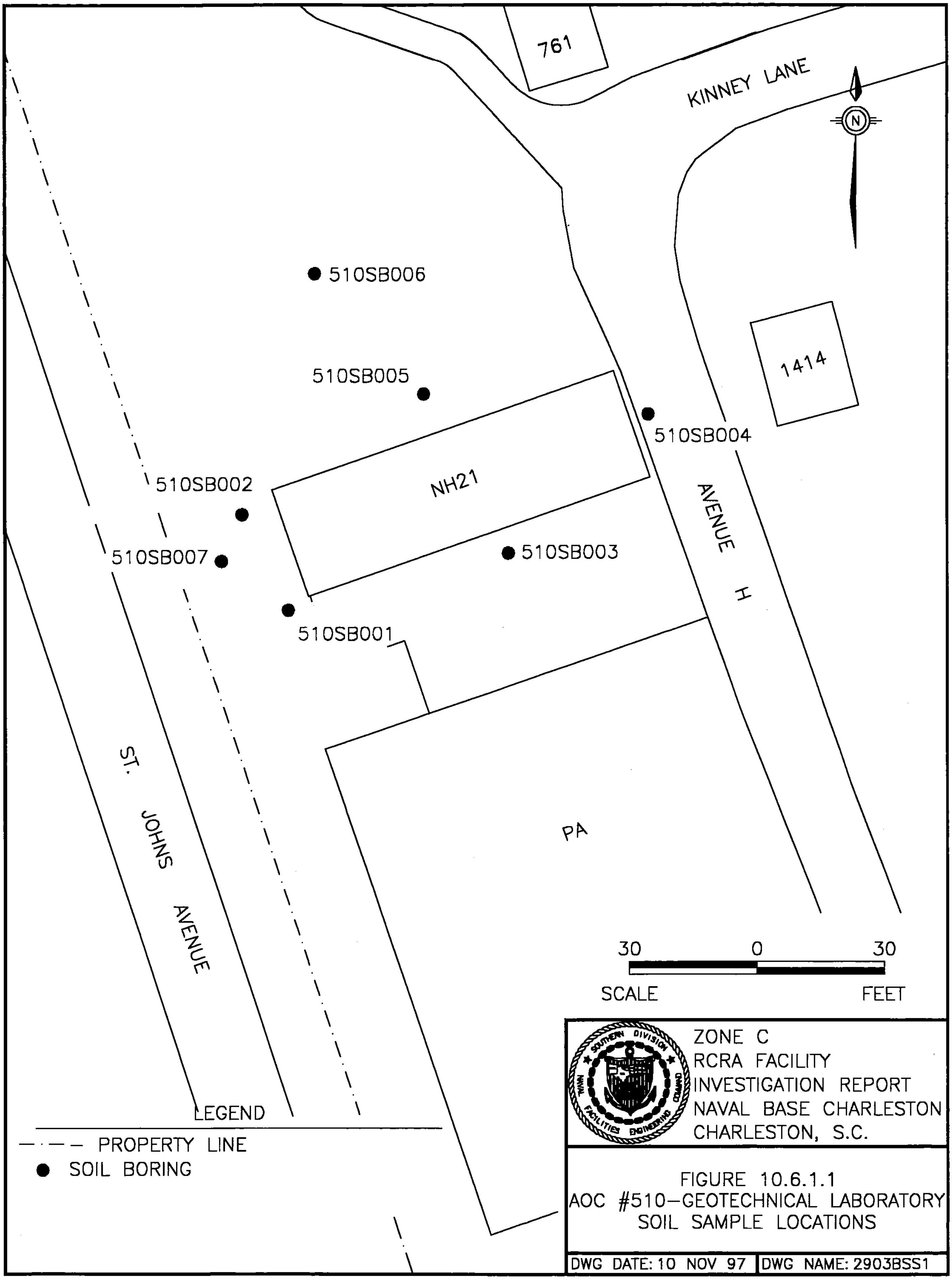
AOC 510, Building NH-21, has been a geotechnical laboratory since 1977, but has operated as a fireproof warehouse (1919 to 1947), a washroom (1947 to 1955), a paint shop (1955 to 1962), and as a storage area (1962 to 1977). A CSI was performed at AOC 510 to identify impacts, if any, to soil or groundwater from possible releases of paint, washroom wastewater discharges, or laboratory chemicals onsite. Potential contaminants include paints and laboratory solvents (acetone, methylene chloride, etc.).

The *Final Zone C RFI Work Plan* (E/A&H, November 1995) required residue samples to be collected from a pit on the west of Building NH-21; however, no samples were collected since no sediment, liquid, or other residue was observed in the pit. To assess whether a release had occurred, soil borings were advanced outside the pit.

10.6.1.1 Soil Sampling and Analysis

Soil was sampled in accordance with the *Final Zone C Work Plan* (E/A&H, November 1995) and Section 3 of this report. Sampling locations were selected following review of historical maps of the area and were placed at locations most likely impacted if a release had occurred. Soil sample locations are shown on Figure 10.6.1.

Soil was sampled in two rounds. During the first round, 10 soil samples were collected from five locations, where five upper and five the lower interval samples were collected per location.



ZONE C
RCRA FACILITY
INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 10.6.1.1
AOC #510–GEOTECHNICAL LABORATORY
SOIL SAMPLE LOCATIONS

DWG DATE: 10 NOV 97 | DWG NAME: 2903BSS1

First-round samples were analyzed for VOCs, SVOCs, pesticides/PCBs, metals, and cyanide at DQO Level III. One duplicate soil sample was submitted for Appendix IX analyses at DQO Level IV which includes the parameters listed above as well as herbicides, hexavalent chromium, organophosphorous pesticides, and dioxins. Table 10.6.1.1 summarizes the first-round soil sampling and analysis.

Table 10.6.1.1
First Round — Soil Sampling and Analysis
AOC 510 — Geotechnical Laboratory

Interval	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
Upper	5	5	Standard Suite[a]	Standard Suite[a]	None
Lower	5	5	Standard Suite[a]	Standard Suite[a]	None

Note:
[a] = Standard Suite includes VOCs, SVOCs, metals, cyanide, and pesticide/PCBs.

First-round soil data were compared to the USEPA Region III *Risk-Based Concentration Table*; June 1996. This preliminary review indicated that BaP exceeded its RBC of 88 μg/kg at two locations, 510SB001 and 510SB005. During the second round of sampling, two supplemental soil sample locations were added to delineate the extent of SVOC contamination. One upper interval soil sample collected from each location was submitted for SVOC analysis. Second-round soil sampling and analysis are summarized in Table 10.6.1.2.

Table 10.6.1.2
Second Round — Soil Sampling and Analysis Summary
AOC 510 — Geotechnical Laboratory

Interval	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Collected	Deviations
Upper	0	2	SVOCs	SVOCs	Added
Lower	0	0	None	None	None

10.6.1.2 Nature and Extent of Contamination

Soil analytical results for organics are in Table 10.6.1.3, and results for inorganics are in Table 10.6.1.4. Appendix D is a complete analytical report for Zone C, and Appendix H contains detection only summary tables.

Table 10.6.1.3
Organic Compound Analytical Results for Soil
AOC 510 — Geotechnical Laboratory

Compound	Sample Interval	Frequency of Detection	Range of Detection	Mean	RBC[a]	Number of Samples Exceeding RBC
Volatile Organic Compounds (μg/kg) (Upper Interval — 5 Samples / Lower Interval — 5 Samples plus 1 Duplicate)						
Chloroform	Upper	1/5	2.0	NA	100,000	0
Toluene	Upper	3/5	3.0 - 7.0	4.67	1,600,000	0
Trichlorofluoromethane	Upper	1/5	22.0	NA	2,300,000	0
Semivolatile Organic Compounds (μg/kg) (Upper Interval — 7 Samples / Lower interval — 5 Samples plus 1 Duplicate)						
Acenaphthene	Upper	1/7	56.0	NA	470,000	0
Anthracene	Upper	1/7	91.0	NA	2,300,000	0
Benzo(a)anthracene	Upper	4/7	55.0 - 370.0	161.25	880[b]	0
Benoz(a)pyrene	Upper	2/7	190.0 - 430.0	310.0	88	2
Benzo(b)fluoranthene	Upper	3/7	74.0 - 930.0	491.3	880[b]	1
Benzo(g,h,i)perylene	Upper	2/7	90.0 - 150.0	120.0	2,300,000	0
Benzo(k)fluoranthene	Upper	3/7	77.0 - 810.0	455.67	8,800[b]	0
Bis(2-ethylhexyl) phthalate	Upper	1/7	120.0	NA	46,000	0
Chrysene	Upper	4/7	43.0 - 370.0	175.75	8,800[b]	0
Di-n-butylphthalate	Lower	1/6	57.0	NA	12,000	0
Fluoranthene	Upper	4/7	63.0 - 990.0	360.75	310,000	0

Table 10.6.1.3
Organic Compound Analytical Results for Soil
AOC 510 — Geotechnical Laboratory

Compound	Sample Interval	Frequency of Detection	Range of Detection	Mean	RBC[a]	Number of Samples Exceeding RBC
Indeno(1,2,3-cd)pyrene	Upper	2/7	89.0 - 150.0	119.5	880[b]	0
Phenanthrene	Upper	2/7	59.0 - 670.0	364.0	230,000	0
Pyrene	Upper	4/7	68.0 - 600.0	233.0	230,000	0
Benzo(a)pyrene BEQs	Upper	4/7	6.05 - 583.0	218	88.0	2
Pesticide and PCB Compounds (μg/kg) (Upper Interval — 5 Samples / Lower Interval — 5 Samples plus 1 Duplicates)						
Aldrin	Upper	1/5	2.5	NA	38	0
beta-BHC	Upper	4/5	1.9 - 24.0	8.05	350	0
Chlordane	Upper	2/5	2.0 - 4.2	3.1	490	0
4,4-DDD	Upper	2/5	5.1 - 7.7	6.4	2,700	0
4,4-DDE	Upper	3/5	24.0 - 110.0	55.67	1,900	0
	Lower	1/5	4.0	NA	500	0
4,4-DDT	Upper	2/5	3.8 - 65.0	34.4	1,900	0
Dieldrin	Upper	1/5	5.5	NA	40	0
Endosulfan sulfate	Upper	1/5	3.60	NA	47,000	0
Endrin aldehyde	Upper	3/5	1.2 - 2.6	1.97	230,000	0
Heptachlor epoxide	Upper	1/5	2.10	NA	70	0
Methoxychlor	Upper	2/5	7.5 - 34.0	20.75	39,000	0

Table 10.6.1.3
Organic Compound Analytical Results for Soil
AOC 510 — Geotechnical Laboratory

Compound	Sample Interval	Frequency of Detection	Range of Detection	Mean	RBC[a]	Number of Samples Exceeding RBC
Other Organic Compounds						
Organophosphorous Pesticides (μg/kg) (Lower Interval - 1 Duplicate Sample)						
Methyl parathion	Lower	1/1	4.9	NA	4.1	1
Parathion	Lower	1/1	5.2	NA	390	0
Herbicide Compounds (μg/kg) (Lower Interval - 1 Duplicate Sample)						
2,4,5-Trichlorophenoxyacetate	Lower	1/1	11.0	NA	22	0
Dioxins (ng/kg) (Lower Interval — 1 Duplicate Sample)						
1234678-HpCDD	Lower	1/1	9.997	NA	NA	NA
1234678-HpCDF	Lower	1/1	6.233	NA	NA	NA
123478-HxCDF	Lower	1/1	0.54	NA	NA	NA
123789-HxCDF	Lower	1/1	0.494	NA	NA	NA
OCDD	Lower	1/1	67.554	NA	NA	NA
OCDF	Lower	1/1	12.6	NA	NA	NA
TEQ Sum	Lower	1/1	.35	NA	1,000	0

Notes:
[a] = Noncarcinogenic RBCs were adjusted equate to a hazard quotient of 0.1.
[b] = These compounds are cPAHs and were multiplied by the appropriate BEF for comparison as BEQs.
All results are in micrograms per kilogram (μg/kg) except dioxins which are in nanograms per kilogram (ng/kg).

Table 10.6.1.4
Soil Inorganics Analytical Results for Soil
AOC 510 — Geotechnical Laboratory

Analyte	Sample Interval	Frequency of Detection[a]	Range of Detection (mg/kg)	Mean (mg/kg)	Reference Conc. (mg/kg)	Number of Samples Exceedances
Aluminum	Upper	5/5	4,010 - 6,570	4,678.00	9,990	0
	Lower	5/5	1,300 - 4,500	2,421	23,700	0
Arsenic	Upper	3/5	0.87 - 2.00	1.52	14.2	0
Barium	Upper	5/5	11.5 - 32.1	22.00	77.2	0
	Lower	5/5	4.6 - 14.1	8.20	68.5	0
Cadmium	Upper	2/5	0.05 - 0.06	0.055	0.65	0
Calcium	Upper	5/5	530 - 2,170	1,106	NA	0
	Lower	5/5	45.5 - 219.0	161.3	NA	0
Chromium	Upper	5/5	2.4 - 7.3	5.42	26.4	0
	Lower	5/5	1.1 - 4.0	2.18	12.5	0
Cobalt	Upper	5/5	0.20 - 0.85	0.59	3.22	0
	Lower	5/5	0.12 - 0.48	0.256	7.1	0
Copper	Upper	4/5	4.0 - 6.9	5.90	34.7	0
	Lower	3/5	0.265 - 0.940	0.505	42.2	0
Iron	Upper	5/5	1,840 - 4,610	3,358.00	NA	0
	Lower	5/5	1,170 - 3,320	1,885	NA	0
Lead	Upper	5/5	7.7 - 60.2	36.1	330	0
	Lower	5/5	2.1 - 7.6	3.49	73.2	0
Magnesium	Upper	5/5	141.0 - 357.0	241.80	NA	0
	Lower	5/5	71.55 - 188.0	121.75	NA	0
Manganese	Upper	5/5	17.5 - 56.1	38.34	92.5	0
	Lower	5/5	8.1 - 20.9	13.98	106	0
Mercury	Upper	2/5	0.23 - 0.28	0.26	0.24	1
Nickel	Upper	5/5	0.69 - 2.0	1.27	12.3	0
	Lower	3/5	0.72 - 0.98	0.853	16.7	0

Table 10.6.1.4
Soil Inorganics Analytical Results for Soil
AOC 510 — Geotechnical Laboratory

Analyte	Sample Interval	Frequency of Detection[a]	Range of Detection (mg/kg)	Mean (mg/kg)	Reference Conc. (mg/kg)	Number of Samples Exceedances
Potassium	Upper	5/5	67.5 - 176.0	107.84	NA	0
	Lower	5/5	33.1 - 123.0	71.22	NA	0
Selenium	Upper	2/5	0.46 - 0.47	0.47	1.44	0
	Lower	2/5	0.48 - 0.62	0.55	2.90	0
Sodium	Upper	3/5	124.0 - 272.0	174.33	NA	0
	Lower	2/5	126.0 - 127.0	126.5	NA	0
Tin	Upper	3/5	1.1 - .15	1.23	2.95	0
	Lower	1/5	1.1	NA	2.37	0
Vanadium	Upper	5/5	2.7 - 9.3	7.02	23.4	0
	Lower	5/5	1.5 - 6.3	3.21	56.9	0
Zinc	Upper	5/5	5.7 - 71.7	48.90	159	0
	Lower	5/5	3.2 - 9.1	4.96	243	0

Volatile Organic Compounds in Soil

Three VOCs were detected in soil samples (chloroform, toluene, and trichlorofluoromethane); however, all were below their respective RBCs.

Semivolatile Organic Compounds in Soil

Fourteen SVOCs were detected in soil samples from AOC 510. BaP and benzo(b)fluoranthene were detected in upper interval samples from 510SB001 and 510SB005 above their respective RBCs. BEQs were calculated for each sample where cPAHs were detected and were compared to the RBC for BaP of 88 μg/kg. There were exceedances in the upper interval samples at 510SB001 and 510SB005. Di-n-butylphthalate was the only SVOC detected in subsurface soil and it was below its SSL.

Pesticides and PCBs in Soil

Eleven pesticide compounds were detected in soil samples from AOC 510, but all were below their respective RBCs. 4,4-DDE was detected in the lower interval, but was below its SSL. No PCBs were detected in soil samples collected from AOC 510.

Other Organic Compounds in Soil

Other organic compounds include the Appendix IX compound groups that are not part of the standard analytical suite, including herbicides, organophosphorous pesticides, and dioxins.

Two organophosphorous pesticides were detected — methyl parathion and parathion. Parathion was detected below its SSL, but methyl parathion (4.9 μg/kg) was detected above its SSL of 4.1 μg/kg. However, both were below their respective RBCs. One herbicide, 2,4,5-trichlorophenoxyacetate acid (2,4,5-T), was detected in the duplicate sample below its RBC of 78,000 μg/kg.

Six dioxins were detected in the duplicate soil sample submitted for Appendix IX analyses. The TEQ for this sample was calculated to be 0.35 ng/kg, which is below the TCDD RBC of 1,000 ng/kg.

Inorganic Elements in Soil

Table 10.6.1.4 summarizes the inorganic analytical results for AOC 510 soil. Twenty inorganic analytes were detected in the upper interval, and 17 were detected in the lower interval. All inorganic analytes were detected below their respective reference concentrations except mercury. Cyanide was not detected in soil samples from AOC 510. Hexavalent chromium was not detected in the duplicate soil sample submitted for Appendix IX analyses.

10.6.1.3 Groundwater Sampling and Analysis

Two monitoring wells were installed to sample the groundwater at AOC 510 (Figure 10.6.1.2). Groundwater was sampled in accordance with the *Final Zone C Work Plan* (E/A&H, November1995) and Section 3 of this report. Groundwater samples were analyzed for VOCs, SVOCs, pesticides/PBCs, metals, and cyanide at DQO Level III. Detected concentrations in groundwater will be further evaluated based on additional groundwater data collected during the subsequent three quarters of sampling. The data are discussed in the Section 11. Table 10.6.1.5 summarizes the groundwater sampling and analysis.

Table 10.6.1.5
Groundwater Sampling and Analysis
AOC 510 — Geotechnical Laboratory

Interval	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
Shallow	2	2	Standard Suite[a]	Standard Suite[a]	None

Note:
[a] = Standard Suite includes VOCs, SVOCs, metals, cyanide, and pesticide/PCBs.

10.6.1.4 Nature and Extent of Groundwater Contamination

Groundwater analytical results for organics are in Table 10.6.1.6, and for inorganics in Table 10.6.1.7. Appendix D is complete report of the analytical data for Zone C, and Appendix H contains detection only summary tables.

Table 10.6.1.6
Organic Compound Analytical Results for Groundwater
AOC 510 — Geotechnical Laboratory

Compound	Frequency of Detection	Range of Detection (μG/L)	Mean (μg/L)	Tap Water RBCs[a] (μg/L)	Number of Samples Exceeding RBCs
Volatile Organic Compounds					
Acetone	½	18.0	NA	370	0

Note:
[a] = Noncarcinogenic RBCs were adjusted to equate to a hazard quotient of 0.1.

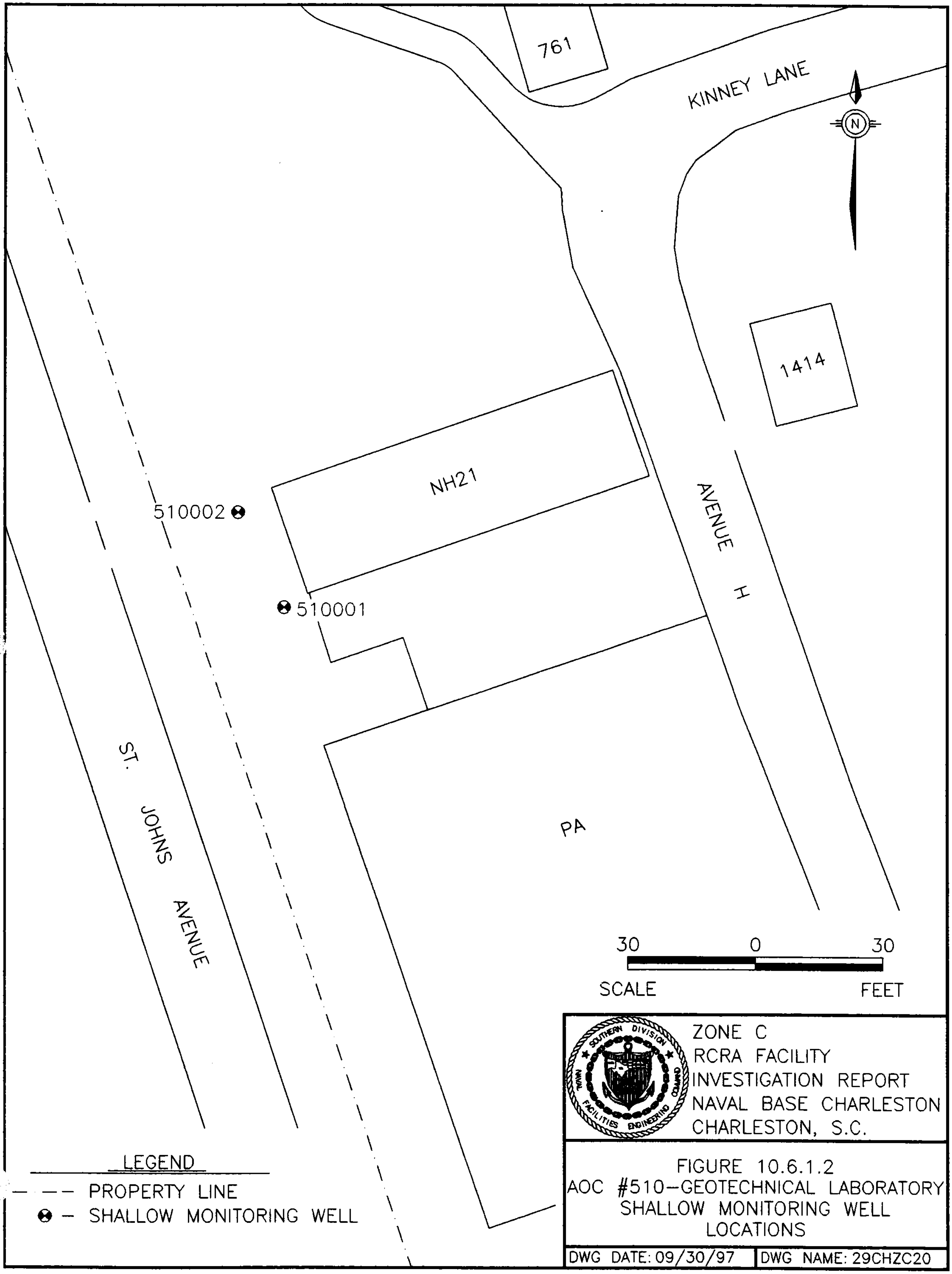


FIGURE 10.6.1.2
AOC #510–GEOTECHNICAL LABORATORY
SHALLOW MONITORING WELL
LOCATIONS

Table 10.6.1.7
Inorganics Analytical Results for Groundwater
AOC 510 — Geotechnical Laboratory

Analyte	Frequency of Detection	Range of Detection (μg/L)	Mean (μg/L)	Reference Conc. (μg/L)	Number of Exceedances
Aluminum	2/2	1,280 - 13,300	7,290.00	410.0	2
Barium	2/2	49.6 - 96.80	73.20	16.7	2
Calcium	2/2	8,600 - 8,670	8,635.00	NA	0
Chromium	2/2	1.9 - 16.6	9.25	1.99	1
Iron	2/2	202 - 2,460	1,331.00	NA	0
Magnesium	2/2	1,340 - 1,800	1,570.00	NA	0
Manganese	2/2	5.5 - 13.0	9.25	608	0
Nickel	½	6.0	NA	3.59	1
Potassium	2/2	2,370 - 2,500	2,435.00	NA	0
Sodium	½	5,990	NA	NA	0
Vanadium	2/2	1.7 - 8.3	5.00	1.96	1
Zinc	2/2	49.3 - 78.9	64.10	13.2	2

Volatile Organic Compounds in Groundwater

Acetone was the only VOC detected in groundwater samples from AOC 510. It was detected at a concentration below its RBC.

Semivolatile Organic Compounds in Groundwater

No SVOCs were detected in the groundwater samples from AOC 510.

Pesticides and PCBs in Groundwater

No pesticides or PCBs were detected in groundwater sample from AOC 510.

Other Organics in Groundwater

Other organic compounds include the Appendix IX compound groups that are not part of the standard analytical suite, including herbicides, organophosphorous pesticides, and dioxins.

No herbicides were detected in groundwater samples from AOC 510. No organophosphorous pesticides were detected in groundwater samples from AOC 510. No dioxins were detected in groundwater samples from AOC 510.

Inorganic Analytes in Groundwater

Twelve inorganic analytes were detected in groundwater samples from AOC 510. Six analytes — aluminum, barium, chromium, nickel, vanadium, and zinc — were detected above their reference concentrations. Three analytes (aluminum, barium, and zinc) were above their reference concentrations in both monitoring wells. Hexavalent chromium was not detected in groundwater samples from AOC 510.

10.6.1.5 Fate and Transport Assessment

AOC 510, currently a geotechnical laboratory in building NH-21, was the site of a fireproof warehouse, a washroom, a paint shop, and a storage area. Migration pathways investigated for AOC 510 include soil-to-groundwater, groundwater-to-surface water and surface soil-to-air. Environmental media sampled as part of the AOC 510 RFI include surface soil, subsurface soil, and shallow groundwater.

10.6.1.5.1 Soil-to-Groundwater Cross-Media Transport

Table 10.6.1.8 compares constituents found in both soil and groundwater with groundwater protection risk-based soil screening levels, tap water RBCs and background reference concentrations. Two constituents (beta-BHC and dieldrin) were detected in AOC 510 soil above

Table 10.6.1.8
Chemicals Detected in Surface Soil, Subsurface Soil and Groundwater
Comparison to Groundwater Protection SSLs, Tap Water RBCs and Background UTLs
NAVBASE-Charleston, Zone C, AOC 510
Charleston, South Carolina

Parameter	Surface Soil Maximum Conc.	Subsurface Soil Maximum Conc.	Ground Water Protection SSL or UTL *	Soil Units	Ground-water Maximum Conc.	Tap Water RBC or UTL *	Water Units	Soil Conc. Exceeds SSL or UTL	Ground-water Conc. Exceeds RBC or UTL
Acenaphthene	56	ND	57000	UG/KG	ND	220	UG/L	NO	NO
Acetone	ND	ND	1600	UG/KG	18	370	UG/L	NO	NO
Aldrin	2.5	ND	500	UG/KG	ND	0.004	UG/L	NO	NO
Aluminum	6570	4500	23700	MG/KG	13300	3700	UG/L	NO	YES
Anthracene	91	ND	1200000	UG/KG	ND	1100	UG/L	NO	NO
Arsenic	2	ND	29	MG/KG	ND	6.07	UG/L	NO	NO
Barium	32.1	14.1	1600	MG/KG	96.8	260	UG/L	NO	NO
Benzo(ghi)perylene	150	ND	46000	UG/KG	ND	150	UG/L	NO	NO
Benzo(a)pyrene Equivalents									
Benzo(a)pyrene	430	ND	8000	UG/KG	ND	0.0092	UG/L	NO	NO
Benzo(a)anthracene	370	ND	2000	UG/KG	ND	0.092	UG/L	NO	NO
Benzo(b)fluoranthene	930	ND	5000	UG/KG	ND	0.092	UG/L	NO	NO
Benzo(k)fluoranthene	810	ND	49000	UG/KG	ND	0.92	UG/L	NO	NO
Chrysene	370	ND	160000	UG/KG	ND	9.2	UG/L	NO	NO
Indeno(1,2,3-cd)pyrene	150	ND	14000	UG/KG	ND	0.092	UG/L	NO	NO
beta-BHC	24	ND	3	UG/KG	ND	0.037	UG/L	YES	NO
Cadmium	0.06	ND	8	MG/KG	ND	1.8	UG/L	NO	NO
Chlordane	10	ND	10000	UG/KG	ND	0.052	UG/L	NO	NO
Chloroform	2	ND	600	UG/KG	ND	0.15	UG/L	NO	NO
Chromium	7.3	4	38	MG/KG	16.6	18	UG/L	NO	NO
Cobalt	0.85	0.48	7.1	MG/KG	ND	220	UG/L	NO	NO
Copper	6.9	0.94	42.2	MG/KG	ND	150	UG/L	NO	NO
4,4'-DDD	7.7	ND	16000	UG/KG	ND	0.28	UG/L	NO	NO
4,4'-DDE	110	4	54000	UG/KG	ND	0.2	UG/L	NO	NO
4,4'-DDT	65	ND	32000	UG/KG	ND	0.2	UG/L	NO	NO
Di-n-butylphthalate	ND	57	2300000	UG/KG	ND	370	UG/L	NO	NO
Dieldrin	5.5	ND	4	UG/KG	ND	0.0042	UG/L	YES	NO
Dioxin (TCDD TEQ)	ND	0.35	4000	PG/G	ND	0.5	PG/L	NO	NO
Endosulfan	3.6	ND	1800	UG/KG	ND	22	UG/L	NO	NO
Endrin	0.72	ND	1000	UG/KG	ND	1.1	UG/L	NO	NO
Endrin aldehyde	2.6	ND	1000	UG/KG	ND	1.1	UG/L	NO	NO
bis(2-Ethylhexyl)phthalate	120	ND	3600000	UG/KG	ND	4.8	UG/L	NO	NO
Fluoranthene	990	ND	430000	UG/KG	ND	150	UG/L	NO	NO
Heptachlor	2.1	ND	23000	UG/KG	ND	0.0023	UG/L	NO	NO
Lead	60.2	7.6	330	MG/KG	ND	15	UG/L	NO	NO
Manganese	56.1	20.9	106	MG/KG	13	557	UG/L	NO	NO
Mercury	0.28	ND	0.3	MG/KG	ND	1.1	UG/L	NO	NO
Methoxychlor	34	ND	160000	UG/KG	ND	18	UG/L	NO	NO
Methylparathion	ND	4.9	6	UG/KG	ND	0.91	UG/L	NO	NO
Nickel	2	0.98	130	MG/KG	6	73	UG/L	NO	NO
Parathion	ND	5.2	8900	UG/KG	ND	22	UG/L	NO	NO
Phenanthrene	670	ND	100000000	UG/KG	ND	150	UG/L	NO	NO
Pyrene	600	ND	420000	UG/KG	ND	110	UG/L	NO	NO
Selenium	0.47	0.62	5	MG/KG	ND	18	UG/L	NO	NO
2,4,5-T	ND	11	450	UG/KG	ND	37	UG/L	NO	NO
Tin	1.5	1.1	2.95	MG/KG	ND	2200	UG/L	NO	NO

Table 10.6.1.8
Chemicals Detected in Surface Soil, Subsurface Soil and Groundwater
Comparison to Groundwater Protection SSLs, Tap Water RBCs and Background UTLs
NAVBASE-Charleston, Zone C, AOC 510
Charleston, South Carolina

Parameter	Surface Soil Maximum Conc.	Subsurface Soil Maximum Conc.	Ground Water Protection SSL or UTL *	Soil Units	Ground-water Maximum Conc.	Tap Water RBC or UTL *	Water Units	Soil Conc. Exceeds SSL or UTL	Ground-water Conc. Exceeds RBC or UTL
Toluene	7	ND	12000	UG/KG	ND	75	UG/L	NO	NO
Vanadium	9.3	6.3	600	MG/KG	8.3	26	UG/L	NO	NO
Zinc	71.7	9.1	1200	MG/KG	78.9	1100	UG/L	NO	NO

* - See Table 6-2
NA - Not available
ND - Not detected
SSL - Groundwater protection soil screening level
UTL - Grid-based background upper tolerance limit
RBC - Tap water risk-based concentration
MG/KG - Milligram per kilogram
UG/KG - Micrograms per kilogram
UG/L - Micrograms per liter

groundwater protection SSLs. Beta-BHC and dieldrin were not detected in subsurface soil or groundwater, which indicates surface soil concentrations sufficiently protect the shallow aquifer.

10.6.1.5.2 Groundwater-to-Surface Water Cross-Media Transport

Aluminum was detected in one of two monitoring wells at a concentration of 13,300 μg/L, which is above the tap water RBC of 3,700 μg/L. Based on the tendency for aluminum to adsorb to the soil matrix, groundwater to surface water migration is not expected to pose a threat to human health or the environment.

10.6.1.5.3 Soil-to-Air Cross-Media Transport

Table 10.6.1.9 lists the volatile organic compounds detected in surface soil samples collected at AOC 510 and corresponding soil-to-air volatilization screening levels. The maximum surface soil concentration of no volatile organic compound exceeded its corresponding soil-to-air volatilization screening level. As a result, the soil-to-air migration pathway would not be expected to be significant at the site.

10.6.1.6 Human Health Risk Assessment for AOC 510

10.6.1.6.1 Site Background and Investigative Approach

AOC 510 (Building NH-21) was investigated to assess soil and groundwater possibly affected by its historical uses and by its current use as a geotechnical laboratory and equipment storage area. The site has been used as a fireproof warehouse (1919-1947), a washroom (1947-1955), a paint shop (1955-1962), and a storage area (1962-1977). Floor staining was observed during the site inspection, and employees indicated that overspray staining from previous painting operations was evident on the floor and walls before the building was converted into a geotechnical laboratory. A covered pit is on the west side of Building NH-21. Seven soils samples were collected from the upper interval at AOC 510. Table 10.6.1.10 lists the analytical methods and parameters

Table 10.6.1.9
Soil-to-Air Volatilization Screening Analysis
NAVBASE - Charleston Zone C, AOC 510
Charleston, South Carolina

VOCs	Maximum Concentratio in Surface Soil	Soil to Air SSL *	Units	Exceeds SSL
Toluene	0.007	650	MG/KG	NO

* - Soil-to-air RBCs were obtained from USEPA Soil Screening Guidance: Technical Background Document, May 1996.

Table 10.6.1.10
Methods Run at AOC 510
Surface Soil

Site	Location	Metal	SVOA	VOA	Cn	Hexa	Diox	Oppe	Herb	Pest	Tph	Otin	Eng
510	B001	Y	Y	Y	Y					Y			
510	B002	Y	Y	Y	Y					Y			
510	B003	Y	Y	Y	Y					Y			
510	B004	Y	Y	Y	Y					Y			
510	B005	Y	Y	Y	Y					Y			Y
510	B006		Y										
510	B007		Y										

METHODS:

- Metal: TAL (Target Analyte List) Metals plus tin: Methods: 6000/7000 Series
- VOA: Volatile Organic Analysis: Method 8240
- SVOA: Semi-volatile Organic Analysis: Method 8270
- Cn: Cyanide (Soil: Method 9010, Water: Method 9012)
- Hexa: Hexavalent Chromium: Method 7195
- Diox: Dioxins
- Oppe: Organophosphate Pesticides: Method 8140
- Herb: Chlorinated Herbicides: Method 8150
- Pest: Chlorinated Pesticides: Method 8080
- Tph: Total Petroleum Hydrocarbons
- Otin: Organotin
- Eng: Engineering Parameters

KEY:

- Y: Analyzed for standard list
- D: Duplicate Analysis
- IR: Method 4181
- DR: Extraction Method 3550, GC Method 8100
- GR: Extraction Method 5030, GC Method 8015

Blank value indicates this method of analysis was not performed

corresponding with site samples. Two monitoring wells were sampled, and shallow groundwater methods area listed in Table 10.6.1.11.

10.6.1.6.2 COPC Identification

Soil

Based on the screening comparisons described in Section 7, this HHRA focuses on BEQ. Screening comparisons are shown in Table 10.6.1.12. No COPCs were added to this HHRA based on the Wilcoxon rank sum test. Results are included in Section 5.

Groundwater

As shown in Table 10.6.1.13, the COPC identified in shallow groundwater for this site is aluminum. No COPCs were added to this HHRA based on the Wilcoxon rank sum test. Results are in Section 5.

10.6.1.6.3 Exposure Assessment

Exposure Setting

Most of the AOC 510 area is covered by asphalt and Building NH-21. Therefore, soil exposure is currently limited to the soil surrounding Building NH-21, where soil samples were collected. A covered pit is on the west side of Building NH-21.

No chemicals are currently used within the unit. However, solvents were used approximately 15 years ago for asphalt extraction. Paints and solvents were used during the paint shop period, and caustics associated with painting operations were stored in a large vat within the unit.

The future use of AOC 510 is unknown, although it is in a section of NAVBASE currently projected as a community support area, near residential areas.

Table 10.6.1.11
Methods Run at AOC 510
Shallow Groundwater, Sampling Round 1

Site	Location	Metal	SVOA	VOA	Cn	Hexa	Diox	Oppe	Herb	Pest	Tph	Otin	Eng
510	W001	Y	Y	Y	Y					Y			
510	W002	Y	Y	Y	Y					Y			

METHODS:

- Metal: TAL (Target Analyte List) Metals plus tin: Methods: 6000/7000 Series
- VOA: Volatile Organic Analysis: Method 8240
- SVOA: Semi-volatile Organic Analysis: Method 8270
- Cn: Cyanide (Soil: Method 9010, Water: Method 9012)
- Hexa: Hexavalent Chromium: Method 7195
- Diox: Dioxins
- Oppe: Organophosphate Pesticides: Method 8140
- Herb: Chlorinated Herbicides: Method 8150
- Pest: Chlorinated Pesticides: Method 8080
- Tph: Total Petroleum Hydrocarbons
- Otin: Organotin
- Eng: Engineering Parameters

KEY:

- Y: Analyzed for standard list
- D: Duplicate Analysis
- IR: Method 4181
- DR: Extraction Method 3550, GC Method 8100
- GR: Extraction Method 5030, GC Method 8015

Blank value indicates this method of analysis was not performed

Table 10.6.1.12
Summary of Chemicals Present in Site Samples, AOC 510
Surface Soil
NAVBASE - Charleston, Zone C
Charleston, South Carolina

	CONC		DETECTS			SCREENING			NON-DETECTS		BACKGROUND	
NAME	**UNITS**	**FREQ**	**Min**	**Max**	**Avg**	**Value**	**# Over**	**Source**	**Min**	**Max**	**Value**	**# Over**
Carcinogenic PAHs												
B(a)P Equiv.	UG/KG	4 - 7	6.05	583.47	217.54	88	2		1368.18	1474.72		
Benzo(a)anthracene	UG/KG	4 - 7	55	370	161.25	880		C	700	760		
Benzo(b)fluoranthene	UG/KG	3 - 7	74	930	491.33	880	1	C	820	880		
Chrysene	UG/KG	4 - 7	43	370	175.75	88000		C	580	620		
Indeno(1,2,3-cd)pyrene	UG/KG	2 - 7	89	150	119.50	880		C	490	530		
Benzo(k)fluoranthene	UG/KG	3 - 7	77	810	455.67	8800		C	660	710		
Benzo(a)pyrene	UG/KG	2 - 7	190	430	310.00	88	2	C	700	760		
Inorganics												
Aluminum (Al)	MG/KG	5 - 5	4010	6570	4678.00	7800		N			9990	
Arsenic (As)	MG/KG	3 - 5	0.87	2	1.52	0.43	3	C	0.57	2.2	14.2	
Barium (Ba)	MG/KG	5 - 5	11.5	32.1	22.00	550		N			77.2	
Cadmium (Cd)	MG/KG	2 - 5	0.05	0.06	0.06	3.9		N	0.03	0.05	0.65	
Calcium (Ca)	MG/KG	5 - 5	530	2170	1106.40	NA						
Chromium (Cr)	MG/KG	5 - 5	2.4	7.3	5.42	39		N			26.4	
Cobalt (Co)	MG/KG	5 - 5	0.2	0.85	0.59	470		N			3.22	
Copper (Cu)	MG/KG	4 - 5	4	6.9	5.90	310		N	1.1	1.1	34.7	
Iron (Fe)	MG/KG	5 - 5	1840	4610	3358.00	NA		N				
Lead (Pb)	MG/KG	5 - 5	7.7	60.2	36.08	400		j			330	
Magnesium (Mg)	MG/KG	5 - 5	141	357	241.80	NA						
Manganese (Mn)	MG/KG	5 - 5	17.5	56.1	38.34	180		N			92.5	
Mercury (Hg)	MG/KG	2 - 5	0.23	0.28	0.26	2.3		N	0.1	0.11	0.24	1
Nickel (Ni)	MG/KG	5 - 5	0.69	2	1.27	160		N			12.3	
Potassium (K)	MG/KG	5 - 5	67.5	176	107.84	NA						
Selenium (Se)	MG/KG	2 - 5	0.46	0.47	0.47	39		N	0.48	0.48	1.44	
Sodium (Na)	MG/KG	3 - 5	124	272	174.33	NA			110	124		
Tin (Sn)	MG/KG	3 - 5	1.1	1.5	1.23	4700			1.6	2.5	2.95	
Vanadium (V)	MG/KG	5 - 5	2.7	9.3	7.02	55		N			23.4	
Zinc (Zn)	MG/KG	5 - 5	5.7	71.7	48.90	2300		N			159	
Chlorinated Pesticides												
Aldrin	UG/KG	1 - 5	2.5	2.5	2.50	38		C	1.1	1.1		

Table 10.6.1.12
Summary of Chemicals Present in Site Samples, AOC 510
Surface Soil
NAVBASE - Charleston, Zone C
Charleston, South Carolina

NAME	CONC UNITS	FREQ	DETECTS Min	DETECTS Max	DETECTS Avg	SCREENING Value	SCREENING # Over	SCREENING Source	NON-DETECTS Min	NON-DETECTS Max	BACKGROUND Value	BACKGROUND # Over
beta-BHC	UG/KG	4 - 5	1.9	24	8.05	350		C	1.1	1.1		
Chlordane	UG/KG	2 - 5	2	4.2	3.10	490		C	4.3	4.3		
4,4'-DDD	UG/KG	2 - 5	5.1	7.7	6.40	2700		C	3.7	3.8		
4,4'-DDE	UG/KG	3 - 5	24	110	55.67	1900		C	3.7	3.8		
4,4'-DDT	UG/KG	2 - 5	3.8	65	34.40	1900		C	3.7	3.8		
Dieldrin	UG/KG	1 - 5	5.5	5.5	5.50	40		C	1.6	1.6		
Endosulfan sulfate	UG/KG	1 - 5	3.6	3.6	3.60	47000		N	2.1	2.1		
Endrin aldehyde	UG/KG	3 - 5	1.2	2.6	1.97	2300		h	1.1	1.1		
Heptachlor epoxide	UG/KG	1 - 5	2.1	2.1	2.10	70		C	1.1	1.1		
Methoxychlor	UG/KG	2 - 5	7.5	34	20.75	39000		N	3.7	3.8		
Semivolatile Organics												
Acenaphthene	UG/KG	1 - 7	56	56	56.00	470000		N	700	760		
Anthracene	UG/KG	1 - 7	91	91	91.00	2300000		N	790	850		
Benzo(g,h,i)perylene	UG/KG	2 - 7	90	150	120.00	310000		f	660	710		
bis(2-Ethylhexyl)phthalate (BEHP)	UG/KG	1 - 7	120	120	120.00	46000		C	800	860		
Fluoranthene	UG/KG	4 - 7	63	990	360.75	310000		N	980	1100		
Phenanthrene	UG/KG	2 - 7	59	670	364.50	310000		f	660	710		
Pyrene	UG/KG	4 - 7	68	600	233.00	230000		N	780	840		
Volatile Organics												
Chloroform	UG/KG	1 - 5	2	2	2.00	100000		C	16	16		
Toluene	UG/KG	3 - 5	3	7	4.67	1600000		N	16	16		
Trichlorofluoromethane	UG/KG	1 - 5	22	22	22.00	2300000		N	22	22		

Notes:
- * Retained as a chemical of potential concern
- C The RBC is based on carcinogenic effects
- N The RBC is based on noncarcinogenic effects
- j Screening level is set equal to the soil action level
- h The RBC for endrin is used as a surrogate
- f The RBC for fluoranthene is used as a surrogate

Table 10.6.1.13
Summary of Chemicals Present in Site Samples, AOC 510
Shallow Groundwater, First Quarter
NAVBASE - Charleston, Zone C
Charleston, South Carolina

NAME	CONC UNITS	FREQ	DETECTS Min	DETECTS Max	DETECTS Avg	SCREENING Value	SCREENING # Over	SCREENING Source	NON-DETECTS Min	NON-DETECTS Max	BACKGROUND Value	BACKGROUND # Over
Inorganics												
Aluminum (Al)	UG/L	2 - 2	1280	13300	7290.00	3700	1	N			410	2
Barium (Ba)	UG/L	2 - 2	49.6	96.8	73.20	260		N			16.7	2
Calcium (Ca)	UG/L	2 - 2	8600	8670	8635.00	NA	2					
Chromium (Cr)	UG/L	2 - 2	1.9	16.6	9.25	18		N			1.99	1
Iron (Fe)	UG/L	2 - 2	202	2460	1331.00	1100	1	N				
Magnesium (Mg)	UG/L	2 - 2	1340	1800	1570.00	NA	2					
Manganese (Mn)	UG/L	2 - 2	5.5	13	9.25	84		N			608	
Nickel (Ni)	UG/L	1 - 2	6	6	6.00	73		N	1.4	1.4	3.59	1
Potassium (K)	UG/L	2 - 2	2370	2500	2435.00	NA	2					
Sodium (Na)	UG/L	1 - 2	5990	5990	5990.00	NA	1		4420	4420		
Vanadium (V)	UG/L	2 - 2	1.7	8.3	5.00	26		N			1.96	1
Zinc (Zn)	UG/L	2 - 2	49.3	78.9	64.10	1100		N			13.2	2
Volatile Organics												
Acetone	UG/L	1 - 2	18	18	18.00	370		N	15	15		

Notes:
- * Retained as a chemical of potential concern
- N The RBC is based on noncarcinogenic effects

Potentially Exposed Populations

Potentially exposed populations are current and future site workers. Additional potentially exposed populations are future site residents. Future site resident and worker exposure scenarios were addressed in this risk assessment. The hypothetical future site worker scenario assumed continuous exposure to surface soil conditions and the use of shallow groundwater as a potable water source. Current site workers' exposure would be less than that assumed for the hypothetical future site worker scenario because of their limited soil contact and the fact that groundwater is not currently used onsite as potable or process water. Therefore, future worker assessment is considered protective of current site users. The future site resident scenario was built on the premise that existing buildings would be removed and replaced with dwellings. In addition, the future site residents were assumed to use the shallow aquifer onsite as a source of drinking water.

Exposure Pathways

Exposure pathways for the site workers are dermal contact and incidental ingestion of surface soil, and ingestion of shallow groundwater through potable use. VOCs were not identified as COPCs in the shallow aquifer, and thus inhalation of volatilized groundwater contaminants was not considered a viable exposure pathway. The exposure pathways for future residential land use are the same as those for the future site worker. In addition, the hypothetical future site worker scenario assumed continuous exposure to surface soil and groundwater conditions. Uniform exposure was assumed for all sample locations. Table 10.6.1.14 justifies exposure pathways assessed in this HHRA.

Table 10.6.1.14
Exposure Pathways Summary — AOC 510
NAVBASE — Zone C
Charleston, South Carolina

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Current Land Uses			
Current Site Users/Maintenance	Air, Inhalation of gaseous contaminants emanating from soil	No	Based on the COPCs identified in this HHRA for AOC 510, no significant VOC concentrations were identified at this site.
	Air, Inhalation of chemicals entrained in fugitive dust	No	Exposure to dust generated by site users traversing the area would be minimized by paved, submerged, and/or vegetated soils.
	Shallow groundwater, Ingestion of contaminants during potable or general use	No (Qualified)	Shallow groundwater is not currently used as a source of potable or non-residential water at AOC 510. Future land use assessment is considered to be protective of current receptors.
	Shallow groundwater, Inhalation of volatilized shallow groundwater contaminants	No	VOCs were not detected in shallow groundwater.
	Soil, Incidental ingestion	No (Qualified)	Future land use assessment is considered to be protective of current receptors.
	Soil, Dermal contact	No (Qualified)	Future land use assessment is considered to be protective of current receptors.
Future Land Uses			
Future Site Residents (Child and Adult) and Future Site Worker	Air, Inhalation of gaseous contaminants emanating from soil	No	Based on the COPCs identified in this HHRA for AOC 510, no significant VOC concentrations were identified at this site.
	Air, Inhalation of chemicals entrained in fugitive dust	No	Exposure to dust generated by site users traversing the area would be minimized by paved and/or vegetated soils.
	Shallow groundwater, Ingestion of contaminants during potable or general use	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Shallow groundwater, Inhalation of volatilized contaminants during domestic use	No	VOCs were not detected in shallow groundwater.
	Soil, Incidental ingestion	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Soil, Dermal contact	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.

Table 10.6.1.14
Exposure Pathways Summary — AOC 510
NAVBASE — Zone C
Charleston, South Carolina

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Future Land Uses			
Future Site Residents (Child and Adult) and Future Site Worker	Wild game or domestic animals, Ingestion of tissue impacted by media contamination	No	Hunting/taking of game and/or raising livestock is prohibited within the Charleston, South Carolina city limits.
	Fruits and vegetables, Ingestion of plant tissues grown in media	No	The potential for significant exposure via this pathway is low relative to that of other exposure pathways assessed.

Exposure Point Concentrations

As discussed in Section 7, UCLs were calculated for datasets consisting of at least 10 samples. Only seven surface soil samples delineate AOC 510: therefore, the maximum concentration reported for BEQs was as EPCs to estimate exposure. Of the seven soil samples collected, BEQ were reported in four of seven, and only two of the four concentrations were reported exceeding the corresponding RBC. The four reported hits were restricted to a small area, which accounts for approximately one-third of the area of investigation (AOI).

When feasible, exposure assessment considers 0.5-acre AOIs (approximately 22,000 square feet). In the AOI identified within AOC 510, approximately 3,300 square feet (of 22,000 square feet) were used to derive an FI/FC accounting for the limited areal extent of the contaminants in surface soil. This factor was conservatively estimated to be 0.2, indicating that the maximum concentrations reported were representative of soil quality of 20% of the potential exposure area. This factor was used to adjust the EPC for BEQs.

Only two shallow monitoring wells were installed onsite. Therefore, the maximum reported aluminum concentration was used to estimate exposure via the groundwater ingestion pathway.

Quantification of Exposure

Soil

CDIs for ingestion and dermal contact with surface soil are shown in Tables 10.6.1.15 and 10.6.1.16, respectively.

Groundwater

The CDIs for groundwater ingestion are presented in Table 10.6.1.17.

10.6.1.6.4 Toxicity Assessment

Toxicity assessment terms and methods are discussed in Section 7. In the following paragraphs, each COPC identified at AOC 510 is profiled and discussed. Table 10.6.1.18 presents the information used to quantify risk and hazard associated with soil and groundwater COPCs.

Aluminum is one of the most abundant metals in the earth's crust (7% aluminum), and it is ubiquitous in air and water, as well as soil. This metal is water-soluble, silvery, and ductile, suggesting its usefulness in many processes. Ingesting aluminum can affect the absorption of other elements within the gastrointestinal tract and can alter intestinal function. Aluminum potentially interferes with the absorption of essential nutrients and cholesterol. Another effect on the gastrointestinal system is the inhibition of acetylcholine-induced contractions, which are part of the neuro-muscular system controlling bowel muscles. The effect could explain why aluminum-containing antacids often produce constipation. Aluminum dust is moderately flammable and explosive in heat. Inhaling this dust can cause fibrosis (aluminosis) (Klaassen, et al., 1986, Dreisbach, et al., 1987). No data are available on an applicable SF or the USEPA cancer group. The USEPA Region IV Office of Health Assessment suggested using the provisional oral RfD of 1.0 mg/kg-day. The aesthetic-based SMCL for drinking water is 50 to 200 μg/L (USEPA, Office of Water).

Table 10.6.1.15
Chronic Daily Intakes (CDI)
Incidental Ingestion of Surface Soil (0-1')
AOC 510 Zone C
Naval Base Charleston
Charleston, SC

Chemical	TEF	Fraction Ingested fro Contaminate Source	Exposure Point Concentration (mg/kg)	Potential Future Resident adult H-CDI (mg/kg-day)	Potential Future Resident child H-CDI (mg/kg-day)	Potential Futur Resident lwa C-CDI (mg/kg-day)	Potential Curren Worker adult H-CDI (mg/kg-day)	Potential Current Worker adult C-CDI (mg/kg-day)
Benzo(a)pyrene Equival	1	0.2	0.584	1.60E-07	1.49E-06	1.83E-07	5.71E-08	2.04E-08

NOTES:

TEF toxic equivalency factor relative to Benzo(a)pyrene
lwa lifetime weighted average, used to calculate carcinogenic CDI, RAGS Parts A and B
CDI Chronic Daily Intake in mg/kg-day
H-CDI CDI for hazard quotient
C-CDI CDI for excess cancer risk
* Reflects the estimated fraction of the site impacted by the corresponding COPC.

Table 10.6.1.16
Chronic Daily Intakes (CDI)
Dermal Contact with Surface Soil (0-1')
AOC 510 Zone C
Naval Base Charleston
Charleston, SC

Chemical	TEF	Adjusted Exposure Point Concentration (mg/kg)	Fraction Contacted fro Contaminated Source *	Dermal Absorption Factor (unitless)	Potential Future Resident adult H-CDI (mg/kg-day)	Potential Future Resident child H-CDI (mg/kg-day)	Potential Futur Resident lwa C-CDI (mg/kg-day)	Potential Curren Worker adult H-CDI (mg/kg-day)	Potential Current Worker adult C-CDI (mg/kg-day)
Benzo(a)pyrene Equival	1	0.584	0.2	0.01	6.55E-08	2.16E-07	4.10E-08	4.68E-08	1.67E-08

NOTES:

TEF Toxic Equivalency Factor relative to Benzo(a)pyrene
CDI Chronic Daily Intake in mg/kg-day
H-CDI CDI for hazard quotient
C-CDI CDI for excess cancer risk
- The dermal absorption factor was applied to the exposure point concentration to reflect the different trans-dermal migration of inorganic versus organic chemicals
* Reflects the estimated fraction of the site impacted by the corresponding COPC.

Table 10.6.1.17
Chronic Daily Intakes (CDI)
Ingestion/Inhalation of COPCs in Shallow Groundwater
AOC 510 Zone C
Naval Base Charleston
Charleston, SC

Chemical	Adjusted Exposure Point Concentration (mg/liter)	Potential Future Resident adult H-CDI (mg/kg-day)	Potential Future Resident child H-CDI (mg/kg-day)	Potential Futur Resident lwa C-CDI (mg/kg-day)	Potential Future Worker adult H-CDI (mg/kg-day)	Potential Future Worker adult C-CDI (mg/kg-day)
Aluminum	13.3	3.64E-01	8.50E-01	2.00E-01	1.30E-01	6.40E-02

NOTES:

lwa lifetime weighted average
CDI Chronic Daily Intake
H-CDI Non-carcinogenic hazard based Chronic Daily Intake
C-CDI Carcinogenic risk based Chronic Daily Intake

Table 10.6.1.18
Toxicological Database Informatio
for Chemicals of Potential Concer
AOC 510
NAVBASE Charleston, Zone C

Non-Carcinogenic Toxicity Data

Chemical	Oral Reference Dose (mg/kg/day)		Confidence Level	Critical Effect	Uncertainty Factor Oral	Inhalation Reference Dose (mg/kg/day)	Confidence Level	Critical Effect	Uncertainty Factor Inhalation
Aluminum	1	e			ND	ND			ND
Benzo(a)pyrene Equivalents	ND				ND	ND			ND

NOTES:

a Integrated Risk Information System (IRIS)
b Health Effects Assessment Summary Tables (HEAST)
c HEAST alternative method
d USEPA Region III Screening Tables
e EPA Environmental Criteria and Assessment Office - Cincinnati (provisional)
f Withdrawn from IRIS or HEAST
NA Not applicable or not available
ND Not determined due to lack of information

Table 10.6.1.18
Toxicological Database Informatio
for Chemicals of Potential Concer
AOC 510
NAVBASE Charleston, Zone C

Carcinogenic Toxicity Data

Chemical	Oral Slope Factor [(mg/kg/day)]-1		Inhalation Slope Factor [(mg/kg/day)]-1	Weight of Evidence	Tumor Type
Aluminum	ND		ND	ND	
Benzo(a)pyrene Equivalents	7.3	a		B2	mutagen

Polyaromatic hydrocarbons or BaP equivalents include the following list of COPCs:

Benzo(a)anthracene	TEF	0.1
Benzo(b)fluoranthene	TEF	0.1
Dibenz(a,h)anthracene	TEF	1.0
Benzo(k)fluoranthene	TEF	0.01
Benzo(a)pyrene	TEF	1.0
Indeno(1,2,3-cd)pyrene	TEF	0.1
Chrysene	TEF	0.001

Some PAHs are toxic to the liver, kidney, and blood. However, the toxic effects of the PAHs above have not been well-established. There are no RfDs for the PAHs above due to a lack of data. All PAHs listed above are classified by USEPA as B2 carcinogens, and their carcinogenicity is addressed relative to that of BaP, having an oral SF of 7.3 $(mg/kg\text{-}day)^{-1}$. TEF, also set by USEPA, are multipliers that are applied to the detected concentrations, which are subsequently used to calculate excess cancer risk. These multipliers are discussed further in the exposure and toxicity assessment sections. Most carcinogenic PAHs have been classified as such due to animal studies using large doses of purified PAHs. There is some doubt as to the validity of these listings, and the SFs listed in USEPA's RBC table are provisional. However, these PAHs are carcinogens when the exposure involves a mixture of other carcinogenic substances (e.g., coal tar, soot, cigarette smoke, etc.). As listed in IRIS (search data June 28, 1995), the basis for the BaP B2 classification is a lack of human data specifically linking BaP to a carcinogenic effect. However, multiple animal studies in many species demonstrate BaP to be carcinogenic by numerous routes.

BaP has produced positive results in numerous genotoxicity assays. At the June 1992 CRAVE Work Group meeting, a revised risk estimate for BaP was verified. This section provides information on three aspects of the carcinogenic risk assessment for the agent in question: the USEPA classification and quantitative estimates of exposure. The classification reflects a weight-of-evidence judgment of the likelihood that the agent is a human carcinogen. The quantitative risk estimates are presented in application of a low-dose extrapolation procedure and presented as the risk per mg/kg-day. The unit risk is the quantitative estimate in terms of either risk per μg/L drinking water or risk per $\mu g/m^3$ air breathed. The third form in which risk is presented is drinking water or air concentration providing cancer risks of one in 10,000 or one in 1,000,000. The Carcinogenicity Background Document provides details on the carcinogenicity values found in IRIS. Users are referred to the Oral Reference Dose and Reference Concentration sections for information on long-term toxic effects other than carcinogenicity.

As listed in IRIS (search date June 28, 1995), the basis for the dibenz(a,h)anthracene and benzo(b)fluoranthene B2 classification is no human data but sufficient data from animal bioassays. Benzo(b)fluoranthene produced tumors in mice after lung implantation, intraperitoneal or subcutaneous injection, and skin painting. As listed in IRIS (search date June 28, 1995), the basis for the benzo(a)anthracene B2 classification is no human data but sufficient data from animal bioassays. Benzo(a)anthracene produced tumors in mice exposed by gavage; intraperitoneal, subcutaneous, or intramuscular injection; and topical application. Benzo(a)anthracene produced mutations in bacteria and in mammalian cells, and transformed mammalian cells in culture. As listed in IRIS (search date June 28, 1995) the basis for the benzo(k)fluoranthene B2 classification is no human data but sufficient data from animal bioassays. Benzo(k)fluoranthene produced tumors after lung implantation in mice and when administered with a promoting agent in skin-painting studies. Equivocal results have been found in a lung adenoma assay in mice. Benzo(k)fluoranthene is mutagenic in bacteria (Klaassen, et al., 1986).

Other PAHs — those not classified by USEPA as carcinogens — are toxic to the liver, kidney and blood. This group of PAHs includes compounds such as pyrene, acenaphthene, acenaphthylene, benzo(g,h,i)perylene, and phenanthrene. USEPA determined RfDs for only two of these compounds: pyrene's RfDo of 0.03 mg/kg-day is also used as a surrogate RfDo for phenanthrene. The RfDo for acenaphthene was 0.06 mg/kg-day.

10.6.1.6.5 Risk Characterization

Surface Soil Pathways

Exposure to surface soil onsite was evaluated under both residential and industrial (site worker) scenarios. For these scenarios, the incidental ingestion and dermal contact exposure pathways were evaluated. For noncarcinogenic contaminants evaluated for future site residents, hazard was computed separately to address child and adult exposure. Tables 10.6.1.19 and 10.6.1.20 present the estimated carcinogenic risks and/or HQs associated with the incidental ingestion of and dermal contact with site surface soil, respectively.

Hypothetical Site Residents

The ingestion ILCR (based on adult and child lifetime weighted average) for AOC 510 surface soil is 1E-6. The dermal pathway ILCR is 6E-7. BEQ was the sole contributor for each pathway.

HIs were not estimated for this exposure pathway because noncarcinogenic toxicological information is not available for BEQs.

Hypothetical Site Workers

Site worker ILCRs are 1E-7 and 2E-7 for the ingestion and dermal contact pathways, respectively. BEQ contributed less than 1E-6 to the sum ILCR for both pathways.

HIs were not estimated for this exposure pathway because noncarcinogenic toxicological information is not available for BEQs.

Table 10.6.1.19
Hazard Quotients and Incremental Lifetime Cancer Risks
Incidental Surface Soil Ingestion
AOC 510 Zone C
Naval Base Charleston
Charleston, SC

Chemical	Oral RfD Used (mg/kg-day)	Oral SF Used (mg/kg-day)-1	Potential Future Resident adult Hazard Quotient	Potential Future Resident child Hazard Quotient	Potential Futur Resident lwa ILCR	Potential Curren Worker adult Hazard Quotient	Potential Current Worker adult ILCR
Benzo(a)pyrene Equivale	NA	7.3	ND	ND	1.3E-06	ND	1.5E-07
SUM Hazard Index/ILCR			ND	ND	1E-06	ND	1E-07

NOTES:

- NA Not available
- ND Not Determined due to lack of available information
- lwa lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
- ILCR Incremental Lifetime excess Cancer Risk

Table 10.6.1.20
Hazard Quotients and Incremental Lifetime Cancer Risks
Dermal Contact With Surface Soil
AOC 510 Zone C
Naval Base Charleston
Charleston, SC

Chemical	Dermal Adjustment	Oral RfD Used (mg/kg-day	Oral SF Used (mg/kg-day)-1	Potential Future Resident adult Hazard Quotient	Potential Future Resident child Hazard Quotient	Potential Futu Resident lwa ILCR	Potential Curren Worker adult Hazard Quotient	Potential Current Worker adult ILCR
Benzo(a)pyrene Equiv	0.5	NA	14.6	ND	ND	6.0E-07	ND	2.4E-07
SUM Hazard Index/ILCR				ND	ND	6E-07	ND	2E-07

NOTES:

NA Not available
ND Not Determined due to lack of available information
lwa lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime excess Cancer Risk
- Dermal to absorbed dose adjustment factor is applied to adjust for Oral SF and RfD (i.e., the oral RfD is based on oral absorption efficiency which should not be applied to dermal exposure and dermal CDI)

Most of AOC 510 is covered by asphalt or by Building NH-21, and BEQs are a component commonly found in asphalt. Currently, soil exposure is limited to the soil surrounding Building NH-21, and continuous chronic exposure to surface soil would be limited to maintenance activities if site conditions are not altered.

Groundwater Pathways

Exposure to shallow groundwater onsite was evaluated under both residential and industrial scenarios. The ingestion exposure pathway was evaluated assuming the site groundwater will be used for potable and/or domestic purposes and that an unfiltered well, drawing from the corresponding water-bearing zone, will be installed. For noncarcinogenic contaminants evaluated relative to future site residents, HIs were estimated separately for child and adult receptors. Table 10.6.1.21 presents the risk and hazard estimated for the groundwater exposure pathway.

Hypothetical Site Residents

The shallow groundwater ingestion ILCR was not estimated for hypothetical site residents because no carcinogenic COPCs were identified during the screening process. HIs for the adult and child resident were estimated to be 0.4 and 0.9, respectively. The only contributor to hazard was aluminum.

Hypothetical Site Workers

The shallow groundwater ingestion ILCR was not estimated for hypothetical site workers because no carcinogenic COPCs were identified during the screening process. The HI for the hypothetical site worker resident was estimated to be 0.1. The only contributor to hazard was aluminum.

Current Site Worker

Groundwater is not currently used as a potable water source at Zone C, because municipal water is readily available. As previously mentioned, it is highly unlikely that the site will be developed

Table 10.6.1.21
Hazard Quotients and Incremental Lifetime Cancer Risks
Shallow Groundwater Ingestion
AOC 510 Zone C
Naval Base Charleston
Charleston, SC

Chemical	Oral RfD Used (mg/kg-day)	Oral SF Used (mg/kg-day)-1	Potential Future Resident adult Hazard Quotient	Potential Future Resident child Hazard Quotient	Potential Futur Resident lwa ILCR	Potential Future Worker adult Hazard Quotient	Potential Future Worker adult ILCR
Aluminum	1	NA	0.4	0.9	ND	0.1	ND
SUM Hazard Index/ILCR			0.4	0.9	ND	0.1	ND

NOTES:

NA Not available
ND Not Determined due to lack of available information
lwa lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime excess Cancer Risk

as a residential area, and it is unlikely that a potable-use well would be installed onsite. It is probable that, if residences were constructed onsite and an unfiltered well was installed, the salinity and dissolved solids would preclude this aquifer from being an acceptable potable water source.

COCs Identified

COCs were identified based on cumulative (all pathways) risk and hazard projected for this site. USEPA has established a generally acceptable risk range of 1E-4 to 1E-6, and a HI threshold of 1.0 (unity). In this HHRA, a COC was considered to be any chemical contributing to a cumulative risk level of 1E-6 or whose HQ exceeds 0.1. For carcinogens, this approach is relatively conservative, because a cumulative risk level of 1E-4 (and individual ILCR of 1E-6) is recommended by USEPA Region IV as the trigger for establishing COCs. The COC selection method presented was used to provide a more comprehensive evaluation of chemicals contributing to carcinogenic risk or noncarcinogenic hazard during the RGO development process.

Surface Soil

Hypothetical Site Residents (Future Land Use)

BEQs were identified for this scenario based on the sum ILCR and HI. BEQ concentration contours are shown on Figure 10.6.1.3.

Hypothetical Site Workers (Future Land Use)

No COCs were identified for this scenario based on the sum ILCR and HI.

The extent of BEQ is briefly discussed below. To facilitate this discussion of the extent of COC concentrations, residential soil RBCs were compared to each reported concentration for each COC identified above. RBCs used for this comparison were based on either an ILCR of 1E-6 and/or an HQ of 1.0 (where applicable). BEQs were reported in four of seven surface soil samples, and

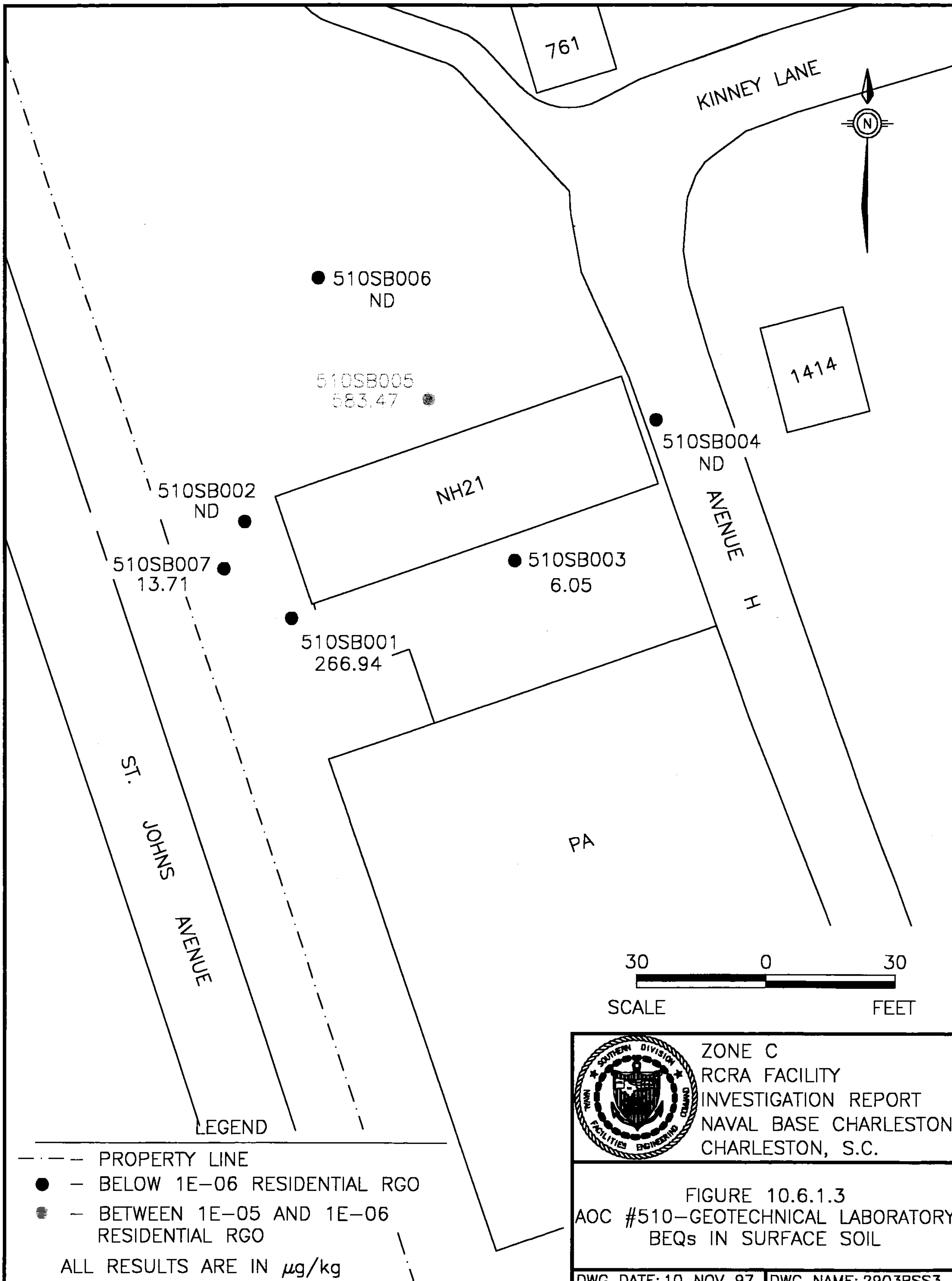


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FIGURE 10.6.1.3
AOC #510–GEOTECHNICAL LABORATORY
BEQs IN SURFACE SOIL

DWG DATE: 10 NOV 97 | DWG NAME: 2903BSS3 two of the four concentrations reported exceed the corresponding RBC. Based on the limited extent of the impacts, an FI/FC factor of 0.2 was conservatively estimated. This factor was used to adjust the EPC for BEQS.

BEQS are a component of asphalt, which could be a source from surficial runoff from the asphalt area onto surface soil locations. Sample locations were not beneath asphalt, although most were near asphalt areas.

Groundwater

Hypothetical Site Residents (Future Land Use)

No COCs were identified in shallow groundwater for this scenario.

Hypothetical Site Workers (Future Land Use)

No COCs were identified in shallow groundwater for this scenario.

No COCs were identified for the groundwater pathway; therefore, no discussion is warranted.

10.6.1.6.6 Risk Uncertainty

Characterization of Exposure Setting and Identification of Exposure Pathways

The potential for high bias is introduced through the exposure setting and pathway selection due to the highly conservative assumptions (i.e., future residential use) recommended by USEPA Region IV when assessing potential future and current exposure. The exposure assumptions made in the site worker scenario are highly protective and would tend to overestimate exposure. Under current site use conditions, workers are infrequently exposed to surface soil when performing maintenance activities or walking across the site. Most of the area is covered by either an asphalt parking area or by Building NH-21.

Residential use of the site would not be expected based on current site uses and the nature of surrounding buildings. Current reuse plans call for use as a community support area. If this area is used as a residential site, Building NH-21 would be demolished, the asphalt parking area surface removed, and surface soil conditions would likely change — soil could be covered with landscaping soil and/or a house. Consequently, exposure to current surface soil conditions would not be likely under a true future residential scenario. These factors indicate that exposure pathways assessed in this HHRA would generally overestimate the risk and hazard posed to site workers and future site residents.

Shallow groundwater is not currently used at AOC 510 for potable or industrial purposes. A basewide system provides drinking and process water to buildings throughout Zone C. This system is scheduled to remain in operation under the current base reuse plan. As a result, shallow groundwater would not be expected to be used under future site use scenarios. Therefore, the scenario established to project risk/hazard associated with shallow groundwater exposure is highly conservative, and associated pathways are not expected to be completed in the future.

Determination of Exposure Point Concentrations

The maximum concentration reported for BEQs was used as the EPC for surface soil. The maximum concentration reported for aluminum was used as the EPC for shallow groundwater. As a result, the quantification of exposure does not account for potential variability in the contaminant concentrations in groundwater.

Frequency of Detection and Spatial Distribution

The use of the maximum concentration as an EPC is questionable for the COC at this site, and the calculated risk and hazard could be skewed up or down because of the low frequency of detection. The biased sampling approach would tend to skew exposure estimates high.

BEQs reported in surface soil at AOC 510 deserve further mention due to the fact that they were detected in only four of the seven samples. The BEQs at only two of these locations exceeded the residential RBC. As a result, the potential for chronic exposure at the EPC is considered low. An FI/FC of 0.2 was used to adjust exposure estimates to account for the limited extent of BEQs. BEQs reported onsite defined a small area, and the percent area of 0.5-acre was determined to be approximately 15%. FI/FC was rounded to 0.2 as a conservative estimate of the AOI. The maximum reported BEQ concentration was adjusted by the FI/FC, and site-wide exposure was assumed. Therefore, site-wide risk projected in this assessment for site workers is considered an overestimate. Alternatively, exposure calculated for the AOI defined by BEQ contains less uncertainty and is a better estimation of RME exposure (within the limited area). All BEQ hits were J-qualified; therefore, confidence in the quantitation is relatively low. This indicates variability is present in the exposure estimates for BEQ.

Quantification of Risk/Hazard

As indicated by the discussions above, the uncertainty inherent in the risk assessment process is great. In addition, many site-specific factors affecting the uncertainty of this assessment that would upwardly bias the risk and hazard estimates. Exposure pathway-specific sources of uncertainty are discussed below.

Soil

Except for arsenic and manganese, CPSSs screened and eliminated from formal assessment because they did not exceed the corresponding RBCs, none was reported at a concentration within 10% of its RBC. This minimizes the likelihood of potentially significant cumulative risk/hazard based on the eliminated CPSSs. Arsenic and manganese exceeded the corresponding RBCs and were eliminated as COPCs based on comparisons to reference concentrations.

BEQs were reported in samples collected near an asphalt-covered lot. BEQ components are constituents of asphalt and its presence is not necessarily attributable to past or current site operation.

Because the future land use of AOC 510 is unknown, both the worker and residential exposure scenarios were assessed in this HHRA. As previously discussed, these scenarios would likely lead to overestimates of risk and/or hazard, especially under RME assumptions. An individual map was not produced for this site.

The CT assumption for residential exposure duration is nine years compared to the 30-year assumption for RME. Changing only this exposure assumption would result in a 66.7% reduction in projected ILCR. If all other exposure assumptions remain fixed, application of the CT exposure duration would result in risk projections below the USEPA acceptable risk threshold of 1E-6.

Groundwater

Groundwater is not currently used as a potable water source at Zone C, because municipal water is readily available. As previously mentioned, it is highly unlikely that the site will be developed as a residential area, and it is unlikely that a potable-use well would be installed onsite. It is probable that, if residences were constructed onsite and an unfiltered well was installed, the salinity and dissolved solids would preclude this aquifer from being an acceptable potable water source. No COPCs were added to this HHRA based on the Wilcoxon rank sum test. Results are in Section 5.

Aluminum concentrations varied considerably in second through fourth-quarter samples ranging from non-detect to 1,870 μg/l. The four quarter mean concentration was, however, comparable to background.

10.6.1.6.7 Risk Summary

The risk and hazard posed by contaminants at AOC 510 were assessed for the hypothetical RME site worker and the hypothetical RME future site resident. In surface soil, the incidental ingestion and dermal contact pathways were assessed in this HHRA. Ingestion was the sole pathway evaluated relative to shallow groundwater. Table 10.6.1.22 summarizes risk for each pathway/receptor group evaluated for AOC 510.

10.6.1.6.8 Remedial Goal Options

Soil

RGOs for the hypothetical site residential scenario were calculated for BEQs, as shown in Table 10.6.1.23. Inclusion in an RGO table does not necessarily indicate that remedial action is warranted. RGOs are options to be considered when making risk management decisions which, in accordance with RAGS, are not to be included in HHRAs.

10.6.1.7 Corrective Measures Considerations for AOC 510

No COCs were identified for groundwater, therefore corrective measures are not required for this medium. BaP equivalents were assessed to be the only COC for surface soil. BEQs were detected in two of seven samples above the RBC. BEQs may not be associated with hazardous constituents managed at this area. However, a corrective measures study will focus on reducing or eliminating risk from BEQs. Potential corrective measures for BEQs in surface soil are shown in Table 10.6.1.24.

Table 10.6.1.22
Summary of Risk and Hazard for AOC 510
NAVBASE - Charleston Zone C
Charleston, South Carolina

Medium	Exposure Pathway	HI (Adult)	HI (Child)	ILCR (LWA)	HI (Worker)	ILCR (Worker)
Surface Soil	Incidental Ingestion	ND	ND	1E-06	ND	1E-07
	Dermal Contact	ND	ND	6E-07	ND	2E-07
Shallow Groundwater	Ingestion	0.4	0.9	ND	0.1	ND
Sum of All Pathways		0.4	0.9	2E-06	0.1	4E-07

Notes:
ND indicates not determined due to the lack of available risk information.
ILCR indicates incremental excess lifetime cancer risk
HI indicates hazard index
LWA indicates lifetime weighted average exposure

Table 10.6.1.23
Residential-Based Remedial Goal Options Surface Soil
AOC 510 Zone C
Naval Base Charleston
Charleston, South Carolina

Chemical	Slope Factor (mg/kg-day)-1	Reference Dose (mg/kg-day)	FI/FC Factor	Unadjusted EPC mg/kg	**Hazard-Based Remedial Goal Options** **3** mg/kg	**1** mg/kg	**0.1** mg/kg	**Risk-Based Remedial Goal Options** **1E-06** mg/kg	**1E-05** mg/kg	**1E-04** mg/kg	Background Concentration mg/kg
Benzo(a)pyrene Equiv	7.3	NA	0.2	0.584	ND	ND	ND	0.30	3.0	30	NA

NOTES:

EPC exposure point concentration
NA not applicable
ND not determined
- remedial goal options were based on the residential lifetime weighted average for carcinogens and the child resident for noncarcinogens

Table 10.6.1.24
Potential Corrective Measures

Medium	Compounds	Potential Corrective Measures
Surface Soil	BaP equivalents	a) No action, monitoring, intrinsic remediation b) Containment/capping c) Excavation, physical and biological treatment d) In-situ, biological treatment

10.6.2 AOC 512 — Former Incinerator

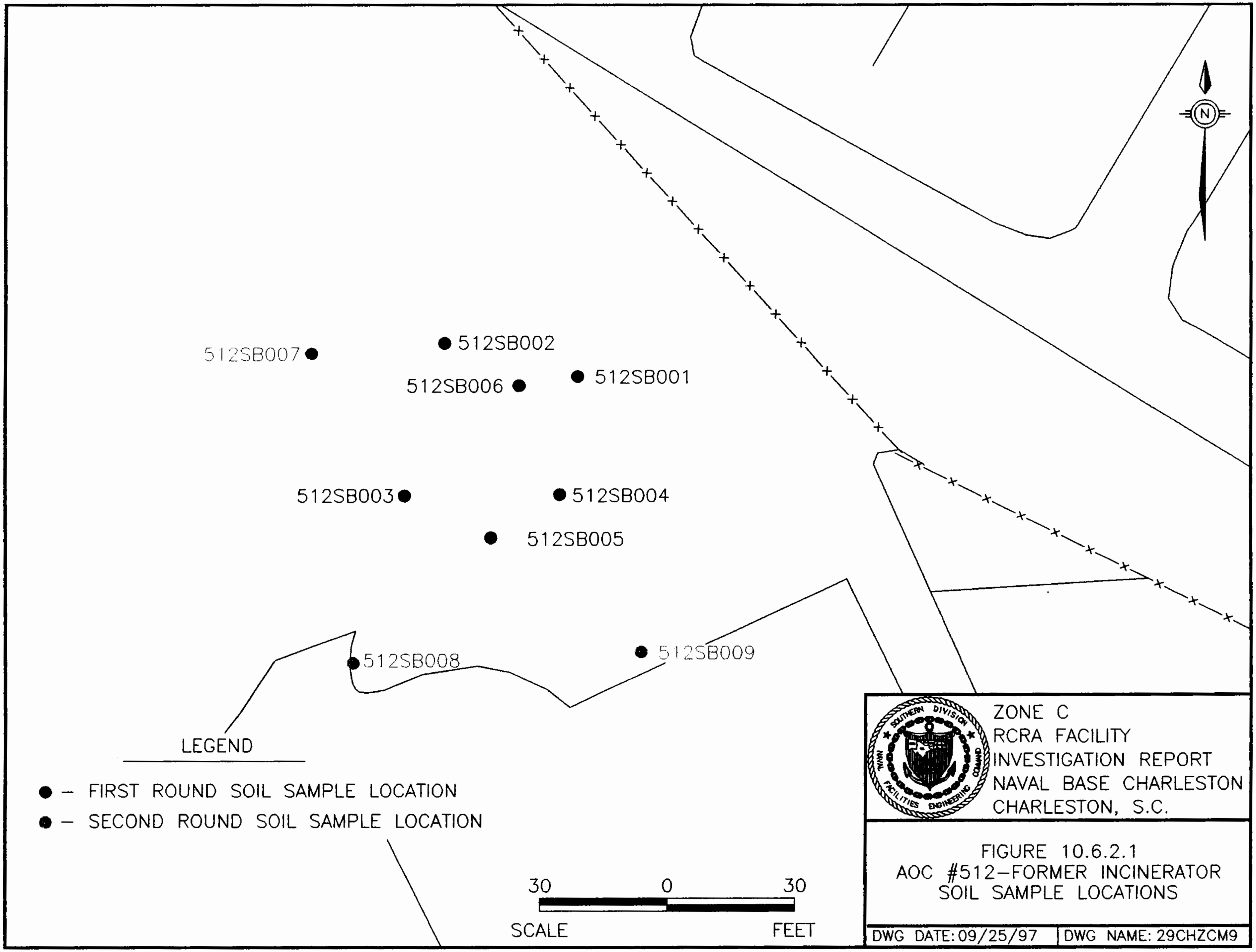
AOC 512 operated as an incinerator from 1943 until 1958. Currently, the site is a grass-covered area approximately 250 feet south west of Building 1079 (Figure 10.6.2.1). Potential contaminants include metals, petroleum hydrocarbons, and residues of incomplete combustion (SVOCs). A CSI was performed at AOC 512 to identify impacts, if any, to site soil from waste incineration onsite.

10.6.2.1 Soil Sampling and Analysis

Soil was sampled in accordance with the *Final Zone C RFI Work Plan* (E/A&H, November 1995) and Section 3 of this report. Sample locations were selected following a review of historic maps of the area and were placed at locations likely impacted if a release had occurred. Figure 10.6.2.1 shows soil sample locations.

Soil was sampled in two rounds. During the first round, seven soil samples were collected from six locations. This included six upper interval soil samples and one lower interval soil sample. A shallow water table inhibited the collection of more lower interval samples since saturated soil samples were not submitted for analysis. First-round samples were analyzed for VOCs, SVOCs, pesticide/PCBs, metals, and cyanide at DQO Level III. One duplicate sample was submitted for Appendix IX analyses at DQO Level IV, which includes the parameters listed above as well as herbicides, hexavalent chromium, organophosphorous pesticides, and dioxins. First-round soil sampling and analysis are summarized in Table 10.6.2.1.

First-round soil data were compared to the USEPA Region III *Risk-Based Concentration Table*; June 1996. This preliminary review data indicated BaP at concentrations above its RBC at locations 512SB001, 512SB002, and 512SB003. Three supplemental sample locations were added to assess the extent of SVOC contamination. Upper interval samples were collected from each location and submitted for SVOCs analysis. Table 10.6.2.2 summarizes the second-round sampling and analysis.



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CHARLESTON, S.C.

FIGURE 10.6.2.1
AOC #512–FORMER INCINERATOR
SOIL SAMPLE LOCATIONS

DWG DATE: 09/25/97 | DWG NAME: 29CHZCM9

Table 10.6.2.1
First Round — Soil Sampling and Analysis Summary
AOC 512 — Former Incinerator

Interval	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
Upper	6	6	Standard Suite[a]	Standard Suite[a]	None
Lower	6	1	Standard Suite[a]	Standard Suite[a]	Shallow water table; saturated soil samples were not submitted for analyses.

Note:
[a] = Standard Suite includes VOCs, SVOCs, metals, cyanide, and pesticides/PCBs.

Table 10.6.2.2
Second Round — Soil Sampling and Analysis Summary
AOC 512 — Former Incinerator

Interval	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
Upper	0	3	SVOCs	SVOCs	Added
Lower	0	0	None	None	None

10.6.2.2 Nature and Extent of Soil Contamination

Soil analytical results for organics are in Table 10.6.2.3, and results for inorganics are in Table 10.6.2.4. Appendix D is the complete analytical report for Zone C, and Appendix H contains detection only summary tables.

Table 10.6.2.3
Organic Compound Analytical Results for Soil
AOC 512 — Former Incinerator

Compound	Sample Interval	Frequency of Detection	Range of Detection	Mean	RBC[a]	Number of Samples Exceeding RBC
Volatile Organic Compounds (μg/kg) (Upper Interval 6 Samples / Lower Interval — 1 Sample)						
Acetone	Lower	1/1	61.0	NA	800	0

Table 10.6.2.3
Organic Compound Analytical Results for Soil
AOC 512 — Former Incinerator

Compound	Sample Interval	Frequency of Detection	Range of Detection	Mean	RBC[a]	Number of Samples Exceeding RBC
Semivolatile Organic Compounds (μg/kg) **(Upper Interval — 9 Samples / Lower Interval — 1 Sample)**						
Benzo(a)anthracene	Upper	7/9	45.0 - 140.0	88.4	880[b]	0
Benzo(a)pyrene	Upper	6/9	60.0 - 120.0	88.9	88[b]	3
	Lower	1/1	850.0	NA	4,000	0
Benzo(b)fluoranthene	Upper	7/9	110.0 - 270.0	198.6	880[b]	0
	Lower	1/1	110.0	NA	4,000	0
Benzo(g,h,i)perylene	Upper	1/9	66.0	66	230,000	0
Benzo(k)fluoranthene	Upper	7/9	95.0 - 300.0	184.3	8,800[b]	0
	Lower	1/1	92.0	NA	4,000	0
Chrysene	Upper	7/9	58.0 - 170.0	96.9	8,800[b]	0
	Lower	1/1	57.0	NA	1,000	0
Fluoranthene	Upper	7/9	76.0 - 240.0	159.4	310,000	0
	Lower	1/1	100.0	NA	980,000	0
Indeno(1,2,3-cd)pyrene	Upper	1/9	60.0	NA	880[b]	0
Phenanthrene	Upper	6/9	49.0 - 120.0	85.2	230,000	0
	Lower	1/1	100.0	NA	98,000	0
Pyrene	Upper	7/9	52.0 - 210.0	106.8	230,000	0
	Lower	1/1	64.0	NA	140,000	0
BEQ	Upper	7/9	16.51 - 170.17	108	88	4
	Lower	1/1[c]	861.98	NA	NA	0

Table 10.6.2.3
Organic Compound Analytical Results for Soil
AOC 512 — Former Incinerator

Compound	Sample Interval	Frequency of Detection	Range of Detection	Mean	RBC[a]	Number of Samples Exceeding RBC
Pesticide and PCB Compounds (μg/kg) (Upper Interval — 6 Samples / Lower Interval — 1 Sample)						
Aldrin	Upper	1/6	1.1	NA	38	0
beta-BHC	Upper	3/6	1.6 - 8.4	5.6	350	0
4,4-DDD	Upper	2/6	4.1 - 37	20.6	2,700	0
	Lower	1/1	57	NA	700	0
4,4-DDE	Upper	5/6	4.3 - 165.0	39.5	7,900	0
	Lower	1/1	180	NA	500	0
4,4-DDT	Upper	3/6	7.6 - 61.0	29.9	1,900	0
Chlordane	Upper	2/6	3.1 - 4.2	3.7	490	0
Dieldrin	Upper	1/6	2.0	2.0	40	0
Endosulfan I	Upper	1/6	2.4	2.4	47,000	0
Endrin aldehyde	Upper	4/6	1.6 - 13	5.1	230,000	0
Methoxychlor	Upper	1/6	4.3	NA	39,000	0
PCB Compounds (μg/kg) (Upper Interval — 6 Samples / Lower Interval — 1 Sample)						
Aroclor-1254	Upper	1/6	60	NA	1,600	0
Aroclor-1260	Lower	1/1	220	NA	8,200	0
Other Organic Compounds						
Herbicide Compounds (μg/kg) (Upper Interval — 1 Duplicate Sample)						
2,4,5-Trichlorophenoxyacetic acid	Upper	1/1	8.5	NA	78,000	0

Table 10.6.2.3
Organic Compound Analytical Results for Soil
AOC 512 — Former Incinerator

Compound	Sample Interval	Frequency of Detection	Range of Detection	Mean	RBC[a]	Number of Samples Exceeding RBC
Organophosphorous Pesticide Compounds (μg/kg) (Upper Interval — 1 Sample)						
Disulfoton	Upper	1/1	5.2	NA	3,100	0
Methyl parathion	Upper	1/1	4.7	NA	2,000	0
Sulfotepp	Upper	1/1	4.5	NA	NA	0
Dioxins (ng/kg) (Upper Interval — 1 Duplicate Sample)						
1234678-HpCDD	Upper	1/1	22.131	NA	NA	NA
1234678-HpCDF	Upper	1/1	9.49	NA	NA	NA
123478-HxCDF	Upper	1/1	3.134	NA	NA	NA
123678-HxCDF	Upper	1/1	1.127	NA	NA	NA
234678-HxCDF	Upper	1/1	1.238	NA	NA	NA
OCDD	Upper	1/1	186.121	NA	NA	NA
OCDF	Upper	1/1	9.778	NA	NA	NA
TCDD TEQ	Upper	1/1	1.06	NA	1,000	0

Notes:
[a] = Noncarcinogenic RBCs were adjusted to equate with a hazard quotient of 0.1.
[b] = These compounds are cPAHs and were multiplied by the appropriate BEF for comparison as BEQs.
[c] = Detected concentrations for duplicate and paired sample were averaged.
All results are in micrograms per kilogram (μg/kg) except for dioxins which are in nanograms per kilogram (ng/kg).

Table 10.6.2.4
Inorganic Analytical Results for Soil
AOC 512 — Former Incinerator
(Upper Interval — 6 Samples/Lower Interval — 1 Sample)

Analyte	Sample Interval	Frequency of Detection[a]	Range of Detection (mg/kg)	Mean (mg/kg)	Reference Conc. (mg/kg)	Number of Samples Exceeding Reference
Aluminum	Upper	6/6	5,510 - 10,600	7,108.00	9,990	1
	Lower	1/1	4,600	NA	23,700	0
Arsenic	Upper	6/6	2.5 - 8.2	5.10	14.2	0
	Lower	1/1	2.4	NA	14.1	0
Barium	Upper	6/6	14.1 - 40.7	23.50	77.2	0
	Lower	1/1	58.8	NA	68.5	0
Beryllium	Upper	4/6	0.27 - 0.44	0.34	ND	4
Cadmium	Upper	5/6	0.21 - 0.77	0.48	0.65	1
Calcium	Upper	6/6	3,045 - 119,000	69,874	NA	0
	Lower	1/1	4,550	NA	NA	0
Chromium	Upper	6/6	9.05 - 21.7	13.58	26.4	0
	Lower	1/1	8	NA	12.5	0
Cobalt	Upper	6/6	0.88 - 4.4	2.56	3.22	2
	Lower	1/1	0.82	NA	7.1	0
Copper	Upper	6/6	10.7 - 39.0	23.40	34.7	1
	Lower	1/1	10.3	NA	42.2	0
Iron	Upper	6/6	4,895 - 11,800	8,527.00	NA	0
	Lower	1/1	3,240	NA	NA	0
Lead	Upper	6/6	21.7 - 76.1	45.80	330	0
	Lower	1/1	37.3	NA	73.2	0
Magnesium	Upper	6/6	405.5 - 2,530	1,602.10	NA	0
	Lower	1/1	397	NA	NA	0

Table 10.6.2.4
Inorganic Analytical Results for Soil
AOC 512 — Former Incinerator
(Upper Interval — 6 Samples/Lower Interval — 1 Sample)

Analyte	Sample Interval	Frequency of Detection[a]	Range of Detection (mg/kg)	Mean (mg/kg)	Reference Conc. (mg/kg)	Number of Samples Exceeding Reference
Manganese	Upper	6/6	43.55 - 280	173.11	92.5	4
	Lower	1/1	39.2	NA	106	0
Mercury	Upper	6/6	0.10 - 0.35	0.19	0.24	1
Nickel	Upper	6/6	2.3 - 9.5	6.20	12.3	0
	Lower	1/1	2.2	NA	16.7	0
Potassium	Upper	6/6	213 - 1,350	762.50	NA	0
	Lower	1/1	242	NA	NA	0
Selenium	Upper	6/6	0.59 - 1.0	0.75	1.44	0
Sodium	Upper	4/6	268 - 344	293.00	NA	0
	Lower	1/1	251	NA	NA	0
Tin	Upper	6/6	1.3 - 1.9	1.60	2.95	0
	Lower	1/1	1.7	NA	2.37	0
Vanadium	Upper	6/6	12.55 - 24.50	17.38	23.4	1
	Lower	1/1	9.2	NA	56.9	0
Zinc	Upper	6/6	38.35 - 124	76.23	159	0
	Lower	1/1	63.2	NA	243	0

Volatile Organic Compounds in Soil

Only one VOC, acetone, was detected in subsurface soil, but it was below the SSL of 800 μg/kg.

Semivolatile Organic Compounds in Soil

Ten SVOCs were detected in soil from AOC 512. Two SVOCs exceeded their respective RBCs, benzo(a)anthracene (four upper interval samples) and BaP (three upper interval samples). Six of the SVOCs detected are cPAHs, including benzo(a)anthracene and BaP. The BEQs calculated for AOC 512 soil indicate exceedances of the BaP RBC of 88 μg/kg at four upper interval samples. None of the subsurface soil samples exceeded their respective SSLs.

Pesticides and PCBs in Soil

Ten pesticide compounds were detected in soil samples from AOC 512; however, all were detected below their respective RBCs or SSLs.

Two PCB compounds were detected in soil samples from AOC 512. Aroclor 1254 was detected below its RBC. Aroclor 1260 was detected below its SSL.

Other Organic Compounds in Soil

Other organic compounds include the Appendix IX compound groups that are not part of the standard analytical suite, including herbicides, organophosphorous pesticides, and dioxins.

One herbicide compound, 2,4,5-trichlorophenoxyacetic acid (2,4,5-T), was detected at 8.5 μg/kg, below the RBC of 78,000 μg/kg.

Three organophosphorous pesticide compounds were detected in soil samples from AOC 512; disulfoton, methyl parathion, and sulfotepp. All were detected at concentrations below their respective RBCs.

Seven dioxins were detected in the duplicate sample submitted for Appendix IX analyses. There are no RBCs established for these parameters. The TEQ for this sample was calculated at 1.06 ng/kg, below the 2,3,7,8-TCDD RBC of 1,000 ng/kg.

Inorganic Elements in Soil

Table 10.6.2.4 summarizes the inorganic analytical data for soil samples collected at AOC 512. Twenty-one analytes were detected in upper interval soil samples; eight analytes — aluminum, beryllium, cadmium, cobalt, copper, manganese, mercury, vanadium — were detected at concentrations above their reference concentrations. Seventeen analytes were detected in lower interval soil samples; however, all were below their respective reference concentrations.

Cyanide and hexavalent chromium were not detected in soil samples collected from AOC 512.

10.6.2.3 Groundwater Sampling and Analysis

Two temporary monitoring wells were installed to sample the groundwater at AOC 512 (Figure 10.6.2.1). Groundwater samples were collected at this site because or the shallow water table and the fact that many of the subsurface samples which are typically available for comparison to SSLs could not be collected. Groundwater was sampled in accordance with the *Final Zone C Work Plan* (E/A&H, February 1995) and Section 3 of this report. Groundwater samples were analyzed for pesticides/PCBs only at DQO Level III. Table 10.6.2.5 summarizes the groundwater sampling and analysis.

Table 10.6.2.5
Groundwater Sampling and Analysis
AOC 512 — Former Incinerator 67

Interval	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
Shallow	0	2	Pesticides/PCBs	Pesticides/PCBs	Added

10.6.2.4 Nature and Extent of Groundwater Contamination

No pesticides or PCBs were detected in groundwater sampled from AOC 512. Therefore, it appears the concentrations present in subsurface soil are sufficiently low to be protective of groundwater. No further investigation is proposed with respect to groundwater for this site.

10.6.2.5 Fate and Transport Assessment

AOC 512, formerly an incinerator, currently is a grassy area adjacent to Building 1079. Environmental media sampled as part of the RFI at AOC 512 include surface and subsurface soil. Potential migration pathways for AOC 512 include constituents leaching from soil to groundwater and emission of volatile constituents from surface soil to air.

10.6.2.5.1 Soil-to-Groundwater Cross-Media Transport

Table 10.6.2.6 compares maximum detected concentrations of chemicals in AOC 512 soil to which ever is greater, groundwater protection SSLs or background reference concentrations. Groundwater was not sampled as part of the AOC 512 RFI.

As a result, no qualitative screening was performed. Four constituents (beta-BHC, disulfoton, manganese, and mercury) were detected in AOC 512 surface soil marginally above groundwater protection SSLs or background reference concentrations. None was detected in subsurface soil above the groundwater protection SSL or grid-based background reference concentration. However, the limited observation does not verify the lack of a migration concern. The concentration of each chemical that failed initial screening was below respective SSLs and/or reference concentrations. This indicates that no widespread threat to groundwater is posed by identified soil samples. Furthermore, two shallow groundwater samples were collected in the source area to confirm or refute the absence of a groundwater threat. These samples were analyzed for chlorinated pesticides and no detections were reported. These findings indicate that current AOC 512 soil quality is protective of the shallow aquifer.

10.6.2.5.2 Soil-to-Air Cross-Media Transport

No volatile organic compounds were detected in AOC 512 surface soil. As a result, the soil-to-air migration pathway is not significant at this site.

Table 10.6.2.6
Chemicals Detected in Surface Soil and Subsurface Soil
Comparison to Groundwater Protection SSLs and Background UTLs
VBASE-Charleston, Zone C, AOC 512
arleston, South Carolina

Parameter	Surface Soil Maximum Conc.	Subsurfac Soil Maximum Conc.	Ground Water Protection SSL or UTL *	Soil Units	Soil Conc. Exceeds SSL or UTL
Parameter	Surface Soil Maximum Conc.	Subsurfac Soil Maximum Conc.	Ground Water Protection SSL or UTL *	Soil Units	Soil Conc. Exceeds SSL or UTL
Acetone	ND	61	1600	UG/KG	NO
Aldrin	1.1	ND	500	UG/KG	NO
Aluminum	10600	4600	23700	MG/KG	NO
Aroclor 1254	60	ND	8600	UG/KG	NO
Aroclor 1260	ND	220	1600	UG/KG	NO
Arsenic	8.2	2.4	29	MG/KG	NO
Barium	40.7	58.8	1600	MG/KG	NO
Benzo(g,h,i)perylene	66	ND	46000	UG/KG	NO
Benzo(a)pyrene Equivalents					
Benzo(a)pyrene	120	850	8000	UG/KG	NO
Benzo(a)anthracene	140	ND	2000	UG/KG	NO
Benzo(b)fluoranthene	270	110	5000	UG/KG	NO
Benzo(k)fluoranthene	300	92	49000	UG/KG	NO
Chrysene	170	57	160000	UG/KG	NO
Indeno(1,2,3-cd)pyrene	60	ND	14000	UG/KG	NO
Beryllium	0.44	ND	63	MG/KG	NO
beta-BHC	8.4	ND	3	UG/KG	YES
Cadmium	0.77	ND	8	MG/KG	NO
Chlordane	4.2	ND	1000	UG/KG	NO
Chromium	21.7	8	38	MG/KG	NO
Cobalt	4.4	0.82	7.1	MG/KG	NO
Copper	39	10.3	42.2	MG/KG	NO
4,4'-DDD	37	57	16000	UG/KG	NO
4,4'-DDE	165	180	54000	UG/KG	NO
4,4'-DDT	61	ND	32000	UG/KG	NO
Dieldrin	2	ND	4	UG/KG	NO
Dioxin (TCDD TEQ)	1.93	ND	4000	PG/G	NO
Disulfoton	5.2	ND	50	UG/KG	NO
Endosulfan	2.4	ND	1800	UG/KG	NO
Endrin aldehyde	13	ND	1000	UG/KG	NO
Fluoranthene	240	100	480000	UG/KG	NO
Lead	76.1	37.3	330	MG/KG	NO
Manganese	280	39.2	106	MG/KG	YES
Mercury	0.35	ND	0.3	MG/KG	YES
Methoxychlor	4.3	ND	160000	UG/KG	NO
Methyl parathion	4.7	ND	6	UG/KG	NO
Nickel	9.5	2.2	130	MG/KG	NO
Phenanthrene	120	100	100000000	UG/KG	NO
ene	210	64	420000	UG/KG	NO
enium	1	ND	5	MG/KG	NO

Table 10.6.2.6
Chemicals Detected in Surface Soil and Subsurface Soil
Comparison to Groundwater Protection SSLs and Background UTLs
`VBASE-Charleston, Zone C, AOC 512
arleston, South Carolina

Parameter	Surface Soil Maximum Conc.	Subsurfac Soil Maximum Conc.	Ground Water Protection SSL or UTL *	Soil Units	Soil Conc. Exceeds SSL or UTL
Sulfotepp	4.5	ND	55	UG/KG	NO
2,4,5-T	8.5	ND	450	UG/KG	NO
Tin	1.9	1.7	2.95	MG/KG	NO
Vanadium	24.5	9.2	600	MG/KG	NO
Zinc	124	63.2	1200	MG/KG	NO

* - See Table 6-2
NA - Not available
ND - Not detected
SSL - Groundwater protection soil screening level
UTL - Grid-based background upper tolerance limit
MG/KG - Milligram per kilogram
UG/KG - Micrograms per kilogram

10.6.2.6 Human Health Risk Assessment

10.6.2.6.1 Site Background and Investigative Approach

AOC 512 operated as an incinerator from 1943 until 1958. Currently, the site is a grass-covered area approximately 250 feet southwest of Building 1079. The purpose of the CSI at AOC 512 was to identify any impacts to surrounding soil from waste incineration activities.

Nine soil samples were collected from the upper interval. Table 10.6.2.7 lists the analytical methods employed for the corresponding samples. The number of soil samples may differ for various compound groups because specific groups were targeted at certain sample locations and/or sampling rounds. Groundwater was not sampled at AOC 512.

10.6.2.6.2 COPC Identification

Soil

Based on the screening comparisons in Section 7 of this RFI and in Table 10.6.2.8, four surface soil COPCs were identified: BEQs, aluminum, beryllium, and manganese. These analytes were identified as COPCs because they exceeded their respective RBCs.

Groundwater

Limited groundwater sampling was conducted in suspected source areas. Samples were analyzed for chlorinated pesticides (EPA Method 8080) only. No pesticides were detected and thus no COPCs were identified for groundwater pathways. The results of this sampling effort were summarized in Section 10.6.2.2.

10.6.2.6.3 Exposure Assessment

Exposure Setting

This grass-covered area just southwest of Building 1079 is in an area slated for community support and/or open buffer space according to base reuse plans.

Table 10.6.2.7
Methods Run at AOC 512
Surface Soil

Site	Location	Metal	SVOA	VOA	Cn	Hexa	Diox	Oppe	Herb	Pest	Tph	Otin	Eng
512	B001	Y	Y	Y	Y					Y			
512	B002	Y	Y	Y	Y					Y			
512	B003	D	D	D	D	Y	Y	Y	Y	D			
512	B004	Y	Y	Y	Y					Y			
512	B005	Y	Y	Y	Y					Y			
512	B006	Y	Y	Y	Y					Y			
512	B007		Y										
512	B008		Y										
512	B009		Y										

METHODS:

- Metal: TAL (Target Analyte List) Metals plus tin: Methods: 6000/7000 Series
- VOA: Volatile Organic Analysis: Method 8240
- SVOA: Semi-volatile Organic Analysis: Method 8270
- Cn: Cyanide (Soil: Method 9010, Water: Method 9012)
- Hexa: Hexavalent Chromium: Method 7195
- Diox: Dioxins
- Oppe: Organophosphate Pesticides: Method 8140
- Herb: Chlorinated Herbicides: Method 8150
- Pest: Chlorinated Pesticides: Method 8080
- Tph: Total Petroleum Hydrocarbons
- Otin: Organotin
- Eng: Engineering Parameters

KEY:

- Y: Analyzed for standard list
- D: Duplicate Analysis
- IR: Method 4181
- DR: Extraction Method 3550, GC Method 8100
- GR: Extraction Method 5030, GC Method 8015

Blank value indicates this method of analysis was not performed

Table 10.6.2.8
Summary of Chemicals Present in Site Samples, AOC 512
Surface Soil
NAVBASE - Charleston, Zone C
Charleston, South Carolina

NAME	CONC UNITS	FREQ	DETECTS Min	DETECTS Max	DETECTS Avg	SCREENING Value	SCREENING # Over	Source	NON-DETECTS Min	NON-DETECTS Max	BACKGROUND Value	BACKGROUND # Over
PCBs												
Aroclor-1254	UG/KG	1 - 6	60	60	60.00	83		C	22	25		
Carcinogenic PAHs												
B(a)P Equiv.	UG/KG	7 - 9	16.508	170.17	107.70	88	4		1461.61	1474.72		
Benzo(a)anthracene	UG/KG	7 - 9	45	140	88.36	880		C	750	760		
Benzo(b)fluoranthene	UG/KG	7 - 9	110	270	198.57	880		C	870	880		
Chrysene	UG/KG	7 - 9	58	170	96.86	88000		C	610	620		
Indeno(1,2,3-cd)pyrene	UG/KG	1 - 9	60	60	60.00	880		C	500	570		
Benzo(k)fluoranthene	UG/KG	7 - 9	95	300	184.29	8800		C	700	710		
Benzo(a)pyrene	UG/KG	6 - 9	60	120	88.92	88	3	C	750	820		
Dioxins												
Dioxin Equiv.	NG/KG	1 - 1	1.062	1.062	1.06	1000						
1234678-HpCDD	NG/KG	1 - 1	22.131	22.131	22.13							
1234678-HpCDF	NG/KG	1 - 1	9.49	9.49	9.49							
123478-HxCDF	NG/KG	1 - 1	3.134	3.134	3.13							
234678-HxCDF	NG/KG	1 - 1	1.238	1.238	1.24							
123678-HxCDF	NG/KG	1 - 1	1.127	1.127	1.13							
OCDD	NG/KG	1 - 1	186.121	186.121	186.12							
OCDF	NG/KG	1 - 1	9.778	9.778	9.78							
Inorganics												
Aluminum (Al)	MG/KG	6 - 6	5250	10600	7108.33	7800	2	N			9990	1
Arsenic (As)	MG/KG	6 - 6	2.5	8.2	5.12	0.43	6	C			14.2	
Barium (Ba)	MG/KG	6 - 6	14.1	40.7	23.47	550		N			77.2	
Beryllium (Be)	MG/KG	4 - 6	0.27	0.44	0.34	0.15	4	C	0.11	0.18		
Cadmium (Cd)	MG/KG	5 - 6	0.21	0.77	0.48	3.9		N	0.06	0.06	0.65	1
Calcium (Ca)	MG/KG	6 - 6	3045	119000	69874.17	NA						
Chromium (Cr)	MG/KG	6 - 6	9.05	21.7	13.58	39		N			26.4	
Cobalt (Co)	MG/KG	6 - 6	0.88	4.4	2.56	470		N			3.22	2
Copper (Cu)	MG/KG	6 - 6	10.7	39	23.38	310		N			34.7	1

Table 10.6.2.8
Summary of Chemicals Present in Site Samples, AOC 512
Surface Soil
NAVBASE - Charleston, Zone C
Charleston, South Carolina

NAME	CONC UNITS	FREQ	DETECTS Min	DETECTS Max	DETECTS Avg	SCREENING Value	SCREENING # Over	Source	NON-DETECTS Min	NON-DETECTS Max	BACKGROUND Value	BACKGROUND # Over
Iron (Fe)	MG/KG	6 - 6	4895	11800	8527.50	NA		N				
Lead (Pb)	MG/KG	6 - 6	21.7	76.1	45.77	400		j			330	
Magnesium (Mg)	MG/KG	6 - 6	405.5	2530	1602.08	NA						
Manganese (Mn)	MG/KG	6 - 6	43.55	280	173.11	180	3	N			92.5	4
Mercury (Hg)	MG/KG	6 - 6	0.1	0.35	0.19	2.3		N			0.24	1
Nickel (Ni)	MG/KG	6 - 6	2.3	9.5	6.17	160		N			12.3	
Potassium (K)	MG/KG	6 - 6	213	1350	762.50	NA						
Selenium (Se)	MG/KG	6 - 6	0.59	1	0.75	39		N			1.44	
Sodium (Na)	MG/KG	4 - 6	268	344	292.75	NA			93.3	194		
Tin (Sn)	MG/KG	6 - 6	1.3	1.9	1.63	4700					2.95	
Vanadium (V)	MG/KG	6 - 6	12.55	24.5	17.38	55		N			23.4	1
Zinc (Zn)	MG/KG	6 - 6	38.35	124	76.23	2300		N			159	
Chlorinated Pesticides												
Aldrin	UG/KG	1 - 6	1.1	1.1	1.10	38		C	1.1	1.2		
beta-BHC	UG/KG	3 - 6	1.6	8.4	5.57	350		C	1.1	1.2		
Chlordane	UG/KG	2 - 6	3.1	4.2	3.65	490		C	4.3	4.4		
4,4'-DDD	UG/KG	2 - 6	4.1	37	20.55	2700		C	3.9	4.2		
4,4'-DDE	UG/KG	5 - 6	4.3	165	39.48	1900		C	3.9	3.9		
4,4'-DDT	UG/KG	3 - 6	7.6	61	29.87	1900		C	3.9	4.2		
Dieldrin	UG/KG	1 - 6	2	2	2.00	40		C	1.7	1.9		
Disulfoton	UG/KG	1 - 1	5.2	5.2	5.20	310		N				
Endosulfan I	UG/KG	1 - 6	2.4	2.4	2.40	47000		N	1.7	1.8		
Endrin aldehyde	UG/KG	4 - 6	1.6	13	5.13	2300		h	1.2	1.2		
Methoxychlor	UG/KG	1 - 6	4.3	4.3	4.30	39000		N	3.9	4.2		
Methyl parathion	UG/KG	1 - 1	4.7	4.7	4.70	2000		N				
Sulfotep	UG/KG	1 - 1	4.5	4.5	4.50	3900		N				
2,4,5-T	UG/KG	1 - 1	8.5	8.5	8.50	78000		N				
Semivolatile Organics												
Benzo(g,h,i)perylene	UG/KG	1 - 9	66	66	66.00	310000		f	670	770		
Fluoranthene	UG/KG	7 - 9	76	240	159.43	310000		N	1000	1100		

Table 10.6.2.8
Summary of Chemicals Present in Site Samples, AOC 512
Surface Soil
NAVBASE - Charleston, Zone C
Charleston, South Carolina

NAME	CONC UNITS	FREQ	DETECTS Min	DETECTS Max	Avg	SCREENING Value	# Over	Source	NON-DETECTS Min	NON-DETECTS Max	BACKGROUND Value	# Over
Phenanthrene	UG/KG	6 - 9	49	120	85.25	310000		f	700	770		
Pyrene	UG/KG	7 - 9	52	210	106.79	230000		N	830	840		

Notes:
- * Retained as a chemical of potential concern
- C The RBC is based on carcinogenic effects
- N The RBC is based on noncarcinogenic effects
- j Screening level is set equal to the soil action level
- h The RBC for endrin is used as a surrogate
- f The RBC for fluoranthene is used as a surrogate

Potentially Exposed Populations

Potentially exposed populations are current and future site workers. Additional potentially exposed populations are hypothetical future site residents. Future site resident and worker exposure scenarios were addressed in this human health risk assessment. The hypothetical future site worker scenario assumes continuous exposure to surface soil conditions. Current site workers' exposure would be less than that assumed for the hypothetical future site worker scenario because of their limited soil contact (the area is currently vegetated) and the fact that groundwater is not currently used onsite. Therefore, future worker assessment is considered to be protective of current site users.

Exposure Pathways

Exposure pathways for the site workers are dermal contact and incidental ingestion of surface soil. The exposure pathways for future residential land use are the same as those for the future site worker. In addition, the hypothetical future site worker scenario assumes continuous exposure to surface soil conditions. Uniform exposure was assumed for all sample locations. Table 10.6.2.9 presents the justification for exposure pathways assessed in this human health risk assessment. Groundwater pathways were not evaluated due to the absence of significant migration potential (soil-to-groundwater), and source area data that indicated the surficial aquifer had not been impacted.

Exposure Point Concentrations

Upper confidence limits are calculated for datasets consisting of at least 10 samples. The maximum concentration of BEQs (0.17 mg/kg), aluminum (10,600 mg/kg), beryllium (0.44 mg/kg), and manganese (280 mg/kg) were used as the soil pathway EPCs, because fewer than 10 samples were collected from the upper interval. A hot-spot approach was used to account for the limited extent of identified impacts. Beryllium was detected in four samples. No FI/FC term was applied to the EPCs for AOC 512.

Table 10.6.2.9
Exposure Pathways Summary — AOC 512
NAVBASE — Zone C
Charleston, South Carolina

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Current Land Uses			
Current Site Users/Maintenance	Air, Inhalation of gaseous contaminants emanating from soil	No	No significant VOC concentrations were reported in surface soils, and portions of the site area are paved/covered by buildings.
	Air, Inhalation of chemicals entrained in fugitive dust	No	Portions of the site area are paved/covered by buildings, which limits fugitive dust generation.
	Shallow groundwater, Ingestion of contaminants during potable or general use	No	Shallow groundwater is not currently used as a source of potable or non-residential water at AOC 512.
	Shallow groundwater, Inhalation of volatilized shallow groundwater contaminants	No	Shallow groundwater is not currently used as a source of potable or non-residential water at AOC 512.
	Soil, Incidental ingestion	No (Qualified)	Future land use assessment is considered to be protective of current receptors.
	Soil, Dermal contact	No (Qualified)	Future land use assessment is considered to be protective of current receptors.
Future Land Uses			
Future Site Residents (Child and Adult) and Future Site Worker	Air, Inhalation of gaseous contaminants emanating from soil	No	No significant VOC concentrations were reported in surface soils, and portions of the site area are paved/covered by buildings.
	Air, Inhalation of chemicals entrained in fugitive dust	No	Portions of the site area are paved/covered by buildings, which limits fugitive dust generation.
	Shallow groundwater, Ingestion of contaminants during potable or general use	No	No groundwater sampling was performed in conjunction with the 512 investigation.
	Shallow groundwater, Inhalation of volatilized contaminants during domestic use	No	No groundwater sampling was performed in conjunction with the 512 investigation.
	Soil, Incidental ingestion	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Soil, Dermal contact	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Wild game or domestic animals, Ingestion of tissue impacted by media contamination	No	Hunting/taking of game and/or raising livestock is prohibited within the Charleston, South Carolina, City Limits.
	Fruits and vegetables, Ingestion of plant tissues grown in media	No	The potential for significant exposure via this pathway is low relative to that of other exposure pathways assessed.

Quantification of Exposure

Soil

Chronic daily intakes for soil ingestion and dermal contact pathways are shown in Tables 10.6.2.10 and 10.6.2.11, respectively.

10.6.2.6.4 Toxicity Assessment

Toxicity assessment terms and methods are discussed in Section 7 of this report. Table 10.6.2.12 presents toxicological information specific to COPCs identified at AOC 512. This information was used in the quantification of risk/hazard associated with soil contaminants. Brief toxicological profiles are provided in the following paragraphs.

Polyaromatic hydrocarbons or BEQs include the following list of COPCs:

Benzo(a)anthracene	TEF	0.1
Benzo(b)fluoranthene	TEF	0.1
Dibenz(a,h)anthracene	TEF	1.0
Benzo(k)fluoranthene	TEF	0.01
Benzo(a)pyrene	TEF	1.0
Indeno(1,2,3-cd)pyrene	TEF	0.1
Chrysene	TEF	0.001

Some PAHs are toxic to the liver, kidneys, and blood. However, the toxic effects of the PAHs above have not been well established. There are no RfDs for the PAHs above due to a lack of data. All PAHs listed above are classified by USEPA as B2 carcinogens, and their carcinogenicity is addressed relative to that of BaP, having an oral SF of 7.3 $mg/kg\text{-}day^{-1}$. Toxicity Equivalency Factors, also set by USEPA, are multipliers that are applied to the detected concentrations, with the results subsequently used to calculate excess cancer risk. These multipliers are discussed further in the exposure and toxicity assessment sections. Most carcinogenic PAHs have been classified as such due to animal studies using large doses of purified PAHs. There is some doubt

Table 10.6.2.10
Chronic Daily Intakes (CDI)
Incidental Ingestion of Surface Soil (0-1')
AOC 512 Zone C
Naval Base Charleston
Charleston, SC

Chemical	TEF	Fraction Ingested fro Contaminate Source	Exposure Point Concentration (mg/kg)	Potential Future Resident adult H-CDI (mg/kg-day)	Potential Future Resident child H-CDI (mg/kg-day)	Potential Futur Resident lwa C-CDI (mg/kg-day)	Potential Curren Worker adult H-CDI (mg/kg-day)	Potential Current Worker adult C-CDI (mg/kg-day)
Benzo(a)pyrene Equival	1	1	0.170	2.33E-07	2.18E-06	2.66E-07	8.33E-08	2.97E-08
Aluminum	NA	1	10600.0	1.45E-02	1.36E-01	1.66E-02	5.19E-03	1.85E-03
Beryllium	NA	1	0.44	6.03E-07	5.63E-06	6.89E-07	2.15E-07	7.69E-08
Manganese	NA	1	280	3.84E-04	3.58E-03	4.38E-04	1.37E-04	4.89E-05

NOTES:

TEF	toxic equivalency factor relative to Benzo(a)pyrene
lwa	lifetime weighted average; used to calculate carcinogenic CDI, RAGS Parts A and B
CDI	Chronic Daily Intake in mg/kg-day
H-CDI	CDI for hazard quotient
C-CDI	CDI for excess cancer risk
*	Reflects the estimated fraction of the site impacted by the corresponding COPC.

Table 10.6.2.11
Chronic Daily Intakes (CDI)
Dermal Contact with Surface Soil (0-1')
AOC 512 Zone C
Naval Base Charleston
Charleston, SC

Chemical	TEF	Adjusted Exposure Point Concentratio (mg/kg)	Fraction Contacted fro Contaminate Source *	Dermal Absorption Factor (unitless)	Potential Future Resident adult H-CDI (mg/kg-day)	Potential Future Resident child H-CDI (mg/kg-day)	Potential Futur Resident lwa C-CDI (mg/kg-day)	Potential Curren Worker adult H-CDI (mg/kg-day)	Potential Current Worker adult C-CDI (mg/kg-day)
Benzo(a)pyrene Equiv	1	0.1702	1	0.01	9.56E-08	3.16E-07	5.98E-08	6.83E-08	2.44E-08
Aluminum	NA	10600	1	0.001	5.95E-04	1.97E-03	3.73E-04	4.25E-04	1.52E-04
Beryllium	1	0.44	1	0.001	2.47E-08	8.16E-08	1.55E-08	1.77E-08	6.30E-09
Manganese	NA	280	1	0.001	1.57E-05	5.19E-05	9.84E-06	1.12E-05	4.01E-06

NOTES:

TEF Toxic Equivalency Factor relative to Benzo(a)pyrene
CDI Chronic Daily Intake in mg/kg-day
H-CDI CDI for hazard quotient
C-CDI CDI for excess cancer risk
- The dermal absorption factor was applied to the exposure point concentration to reflect the different trans-dermal migration of inorganic versus organic chemicals
* Reflects the estimated fraction of the site impacted by the corresponding COPC.

Table 10.6.2.12
Toxicological Database Informatio
for Chemicals of Potential Concer
AOC 512
NAVBASE Charleston, Zone C

Non-Carcinogenic Toxicity Data

Chemical	Oral Reference Dose (mg/kg/day)		Confidence Level	Critical Effect	Uncertainty Factor Oral	Inhalation Reference Dose (mg/kg/day)		Confidence Level	Critical Effect	Uncertainty Factor Inhalation
Aluminum	1	e			ND	ND				ND
Benzo(a)pyrene Equivalents	ND				ND	ND				ND
Beryllium	0.005	a	L	microscopic organ changes	100	ND				ND
Manganese (food)	0.047	a	NA	neurological effects	1	ND				ND
Manganese (water)	0.023	a	NA	neurological effects	1	1.43E-05	a	M	neurological effects	1000

NOTES:

a Integrated Risk Information System (IRIS)
b Health Effects Assessment Summary Tables (HEAST)
c HEAST alternative method
d USEPA Region III Screening Tables
e EPA Environmental Criteria and Assessment Office - Cincinnati (provisional)
f Withdrawn from IRIS or HEAST
NA Not applicable or not available
ND Not determined due to lack of information

Table 10.6.2.12
Toxicological Database Informatio
for Chemicals of Potential Concer
AOC 512
NAVBASE Charleston, Zone C

Carcinogenic Toxicity Data

Chemical	Oral Slope Factor [(mg/kg/day)]-1		Inhalation Slope Factor [(mg/kg/day)]-1		Weight of Evidence	Tumor Type
Aluminum	ND		ND		ND	
Benzo(a)pyrene Equivalents	7.3	a			B2	mutagen
Beryllium	4.3	a	8.4	a	B2	osteosarcoma
Manganese (food)	ND		ND		D	
Manganese (water)	ND		ND		D	

as to the validity of these listings, and the SFs listed in USEPA's RBC table are provisional. However, these PAHs are carcinogens when the exposure involves a mixture of other carcinogenic substances (e.g., coal tar, soot, cigarette smoke, etc.). As listed in IRIS (search data June 28, 1995), the basis for the BaP B2 classification is that human data specifically linking BaP to a carcinogenic effect are lacking. There are however, multiple animal studies in many species demonstrating BaP to be carcinogenic by numerous routes.

BaP has produced positive results in numerous genotoxicity assays. At the June 1992 CRAVE Work Group meeting, a revised risk estimate for BaP was verified (see Additional Comments for Oral Exposure). This section provides information on three aspects of the carcinogenic risk assessment for the agent in question: the USEPA classification and quantitative estimate of exposure; the classification reflects a weight-of-evidence judgment of the likelihood that the agent is a human carcinogen. The quantitative risk estimates are presented in application of a low-dose extrapolation procedure and presented as the risk per mg/kg-day. The unit risk is the quantitative estimate in terms of either risk per μg/l drinking water or risk per $\mu g/m^3$ air breathed. The third form in which risk is presented is drinking water or air concentration providing cancer risks of 1 in 10,000 or 1 in 1,000,000. The Carcinogenicity Background Document provides details on the carcinogenicity values found in IRIS. Users are referred to the Oral Reference Dose and Reference Concentration sections for information on long-term toxic effects other than carcinogenicity.

As listed in IRIS (search data June 28, 1995), the basis for the dibenz(a,h)anthracene and benzo(b)fluoranthene B2 classification is no human data and sufficient data from animal bioassays. Benzo(b)fluoranthene produced tumors in mice after lung implantation, intraperitoneal or subcutaneous injection, and skin painting. As listed in IRIS (search date June 28, 1995), the basis for the benzo(a)anthracene B2 classification is no human data and sufficient data from animal bioassays. Benzo(a)anthracene produced tumors in mice exposed by gavage; intraperitoneal, subcutaneous or intramuscular injection; and topical application. Benzo(a)anthracene produced mutations in bacteria and in mammalian cells, and transformed mammalian cells in culture. As listed in IRIS (search date June 28, 1995), the basis for the benzo(k)fluoranthene B2 classification is no human data and sufficient data from animal bioassays. Benzo(k)fluoranthene produced tumors after lung implantation in mice and when administered with a promoting agent in skin-painting studies. Equivocal results have been found in lung adenoma assay in mice. Benzo(k)fluoranthene is mutagenic in bacteria. Although not specifically referenced in IRIS, 7,12-Dimethylbenz(a)anthracene was considered as a carcinogen in the formal risk assessment. Due to structural similarities, the TEF for benzo(a)anthracene (TEF=0.1) was applied for this compound.

Other PAHs — those not classified by USEPA as carcinogens — are toxic to the liver, kidney, and blood. This group of PAHs includes compounds such as pyrene, acenaphthene, acenaphthylene, benzo(g,h,i)perylene, and phenanthrene. USEPA determined RfDs for only two of these compounds: pyrene's RfDo of 0.03 mg/kg-day is also used as a surrogate RfDo for phenanthrene, while the RfDo for acenaphthene is 0.06 mg/kg-day.

Aluminum is one of the most abundant metals in the earth's crust (7% aluminum), and it is ubiquitous in air, water, and soil. This metal is water soluble, silvery, and ductile, which suggests its usefulness in many processes. Ingesting aluminum can affect the absorption of other elements within the gastrointestinal tract and can alter intestinal function. Aluminum can potentially interfere with the absorption of essential nutrients and cholesterol. Another effect on the gastrointestinal system is the inhibition of acetycholine-induced contractions, which are part of the neuromuscular system controlling bowel muscles. The effect could explain why aluminum-containing antacids often produce constipation. Aluminum dust is moderately flammable and explosive in heat. Inhaling this dust can cause fibrosis (aluminosis) (Klaassen, et al., 1986; Dreisbach, et al., 1987). No data are available on an applicable SF or the USEPA cancer group.

The USEPA Region IV Office of Health Assessment suggested using the provisional oral RfD of 1.0 mg/kg-day. The aesthetic-based SMCL for drinking water is 50 to 200 μg/l (USEPA, Office of Water).

Beryllium exposure via the inhalation route can cause inflammation of the lungs, a condition known as Acute Beryllium Disease, as a result of short-term exposure to high concentrations. Removal from exposure results in a reversal of the symptoms. Chronic exposure to much lower levels of beryllium or beryllium oxide by inhalation has been reported to cause chronic beryllium disease, with symptoms including shortness of breath, scarring of the lungs, and berylliosis, which is noncancerous growths in the lungs of humans. Both forms of beryllium disease can be fatal, depending on the severity of the exposure. Additionally, a skin allergy may develop when soluble beryllium compounds come into contact with the skin of sensitized individuals (Gradient, 1991). An oral RfD of 0.0054 mg/kg-day has been set for beryllium based on a chronic oral bioassay (rats were the study species) which determined no adverse effect occurs at 0.54 mg/kg-day. Beryllium has been classified by USEPA as a group B2 carcinogen based on animal studies. It has been shown to induce lung cancer via inhalation in rats and monkeys, and to induce osteosarcomas in rabbits via intravenous or intramedullary injection. Human epidemiology studies of beryllium are considered to be inadequate. As listed in IRIS (search date June 28, 1995), the basis for the classification is that beryllium has been shown to induce lung cancer via inhalation in rats and monkeys and to induce osteosarcomas in rabbits via intravenous or intramedullary injection. Human epidemiology studies are considered inadequate. An inhalation slope factor of 8.4 mg/kg-day^{-1} and an oral SF of 4.3 mg/kg-day^{-1} have been set by USEPA. As listed in IRIS (search date June 28, 1995), the critical effect of this chemical is no adverse effect. The uncertainty factor was 100 and the modifying factor was 1. The IRIS RfD in drinking water is 0.005 mg/kg-day.

Manganese is an essential nutrient, but chronic exposure (0.8 mg/kg-day) causes mental disturbances. Studies have shown that manganese uptake from water is greater than manganese uptake from food, and the elderly appear to be more sensitive than children (Klaassen, et al., 1986; Dreisbach, et al., 1987). Because of the different uptake rates in water and food, USEPA set two oral RfDs — one for water and one for food. These RfDs are 0.005 and 0.14 mg/kg-day, respectively. Inhalation of manganese dust causes neurological effects and increased incidence of pneumonia. An inhalation RfD was set to 0.0000143 mg/kg-day. According to USEPA, manganese cannot be classified as to its carcinogenicity. Therefore, the cancer class for manganese is group D. As listed in IRIS (search date June 29, 1995), the basis for the classification is existing studies that are inadequate to assess the carcinogenicity of manganese. Manganese is an element considered essential to human health. The typical vitamin supplement dose of manganese is 2.5 mg/day. As listed in IRIS (search date June 29, 1995), the critical effects of this chemical in water in the oral summary are CNS effects. The uncertainty factor was determined to be 1 and the modifying factor was determined to be 1. As listed in IRIS (search date June 29, 1995), the critical effect of this chemical in the inhalation summary is impairment of neuro-behavioral function. The uncertainty factor was 1000 and the modifying factor was 1. The IRIS RfC is 0.00005 mg/m^3.

10.6.2.6.5 Risk Characterization

Surface Soil Pathways

Exposure to surface soil onsite was evaluated under both residential and industrial (site worker) scenarios. For these scenarios, the incidental ingestion and dermal contact exposure pathways were evaluated. For noncarcinogenic contaminants evaluated for future site residents, hazard was computed separately to address child and adult exposure. Tables 10.6.2.13 and 10.6.2.14 present the computed carcinogenic risk and the HQ associated with the incidental ingestion of and dermal contact with site surface soils, respectively.

Table 10.6.2.13
Hazard Quotients and Incremental Lifetime Cancer Risks
Incidental Surface Soil Ingestion
AOC 512 Zone C
Naval Base Charleston
Charleston, SC

Chemical	Oral RfD Used (mg/kg-day)	Oral SF Used (mg/kg-day)-1	Potential Future Resident adult Hazard Quotient	Potential Future Resident child Hazard Quotient	Potential Futur Resident lwa ILCR	Potential Curren Worker adult Hazard Quotient	Potential Current Worker adult ILCR
Benzo(a)pyrene Equivale	NA	7.3	ND	ND	1.9E-06	ND	2.2E-07
Aluminum	1	NA	0.015	0.14	ND	0.0052	ND
Beryllium	0.005	4.3	0.00012	0.0011	3.0E-06	0.00004	3.3E-07
Manganese	0.047	NA	0.008	0.08	ND	0.0029	ND
SUM Hazard Index/ILCR			0.02	0.2	5E-06	0.01	5E-07

NOTES:

NA Not available
ND Not Determined due to lack of available information
lwa lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime excess Cancer Risk

Table 10.6.2.14
Hazard Quotients and Incremental Lifetime Cancer Risks
Dermal Contact With Surface Soil
AOC 512 Zone C
Naval Base Charleston
Charleston, SC

Chemical	Dermal Adjustment	Oral RfD Used (mg/kg-day	Oral SF Used (mg/kg-day)-1	Potential Future Resident adult Hazard Quotient	Potential Future Resident child Hazard Quotient	Potential Futu Resident lwa ILCR	Potential Curren Worker adult Hazard Quotient	Potential Current Worker adult ILCR
Benzo(a)pyrene Equiv	0.5	NA	14.6	ND	ND	8.7E-07	ND	3.6E-07
Aluminum	0.2	0.2	NA	0.003	0.010	ND	0.0021	ND
Beryllium	0.2	0.001	21.5	2.5E-05	8.2E-05	3.3E-07	1.8E-05	1.4E-07
Manganese	0.2	0.0094	NA	0.002	0.006	ND	0.0012	ND
SUM Hazard Index/ILCR				0.005	0.02	1E-06	0.003	5E-07

NOTES:

NA Not available
ND Not Determined due to lack of available information
lwa lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime excess Cancer Risk
- Dermal to absorbed dose adjustment factor is applied to adjust for Oral SF and RfD (i.e., the oral RfD is based on oral absorption efficiency which should not be applied to dermal exposure and dermal CDI)

Hypothetical Site Residents

The ingestion ILCR (based on the adult and child lifetime weighted average) for AOC 512 for surface soil is 5E-6, and the dermal pathway ILCR is 1E-8. The computed HI for the adult and child resident are 0.02 and 0.2, respectively, for the soil ingestion pathway. The dermal contact pathway HIs are 0.002 and 0.01 for the adult resident and the child resident, respectively. BEQs, aluminum, beryllium, and manganese contribute to the cumulative risk/hazard.

Hypothetical Site Workers

Site worker ILCRs are 5E-7 and 5E-7 for the ingestion and dermal contact pathways, respectively. The HIs for both pathways are less than 0.1. BEQs, aluminum, beryllium, and manganese are the contributors to cumulative risk/hazard.

The AOC 512 area is vegetated. Current site users have little chance of exposure to affected surface soil. As a result, the risk/hazard projections discussed above are considered gross overestimates should existing site features be maintained under future use scenarios.

COCs Identified

BEQs and beryllium were identified as the only COCs at AOC 512 based on cumulative (all pathway) risk and hazard projected for this site. USEPA has established a generally acceptable risk range of 1E-4 to 1E-6, and an HI threshold of 1.0 (unity). In this human health risk assessment, a COC was considered to be any chemical contributing to a cumulative risk level of 1E-6 or one whose HQ exceeded 0.1. For carcinogens, this approach is relatively conservative, because a cumulative risk level of 1E-4 (and individual ILCR of 1E-6) is recommended by USEPA Region IV as the trigger for establishing COCs. The COC selection algorithm presented was used to provide a more comprehensive evaluation of chemicals contributing to carcinogenic risk or noncarcinogenic hazard during the remedial goal options development process.

Surface Soils

Hypothetical Site Residents (future land use)

BEQs and beryllium were identified as the soil pathway COCs based on their contributions to cumulative ILCR projections. Isoconcentrations for the COCs are provided in Figures 10.6.2.2 and 10.6.2.3.

Hypothetical Site Workers (future land use)

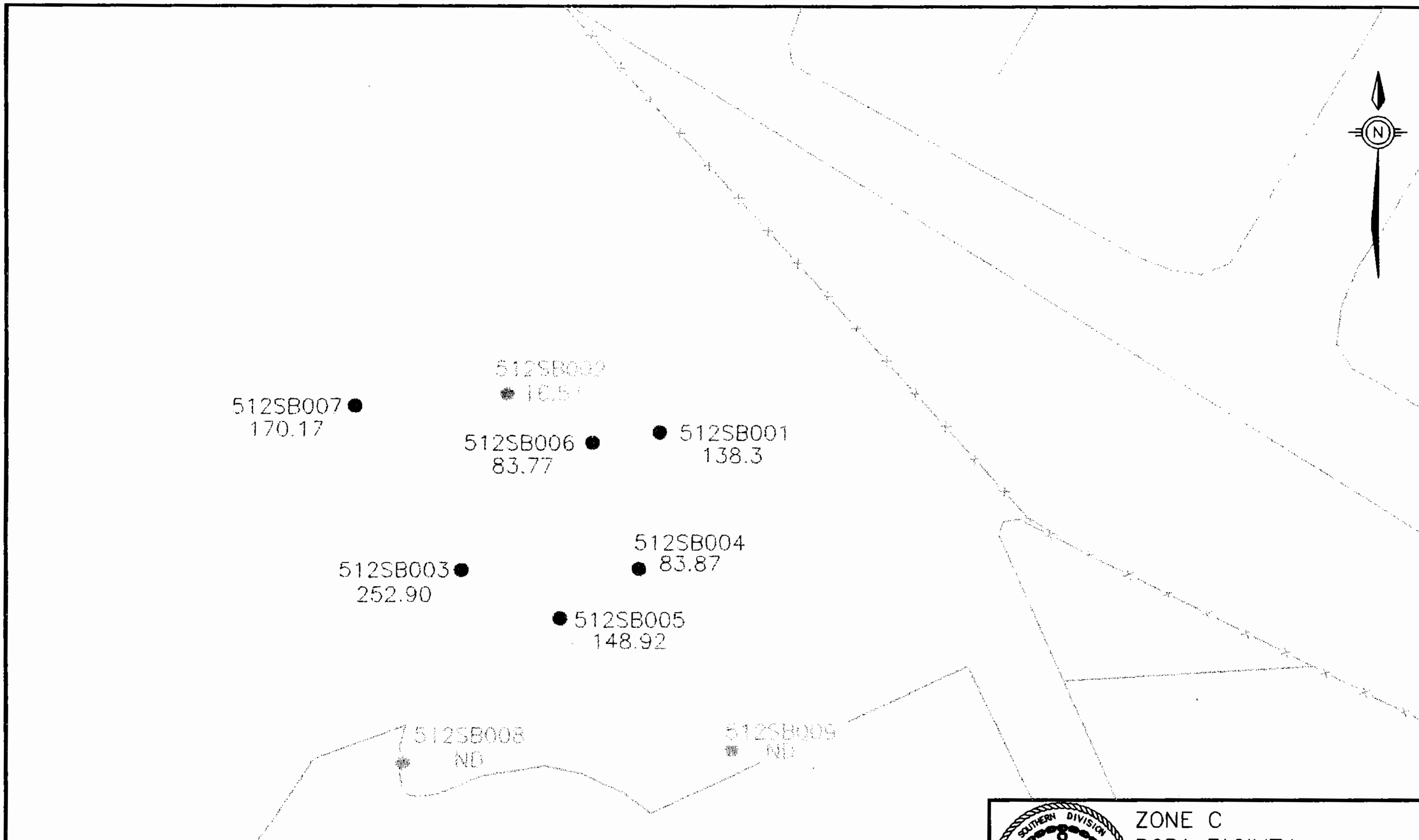
No COCs were identified for this scenario based on the sum ILCR and HI.

The extent of the COCs identified in surface soil is briefly discussed below. Semivolatile BEQs were detected in six of nine upper interval samples collected, with a maximum concentration of 0.17 mg/kg. Of the six detections, four samples exceeded the RBC. The data suggest that the highest concentrations of semivolatile compounds are limited to the area immediately surrounding the former incinerator, because SB008 and SB009 were nondetect for the SVOC scan. Beryllium was detected in four of seven surface soil samples. Detections were generally within and adjacent to the footprint of the former incinerator.

10.6.2.6.6 Risk Uncertainty

Characterization of Exposure Setting and Identification of Exposure Pathways

The potential for high bias introduced through the exposure setting and pathway selection is due to the highly conservative assumptions (i.e., future residential use) recommended by USEPA Region IV when assessing potential future and current exposure. The exposure assumptions made in the site worker scenario are highly protective and would tend to overestimate exposure. Current site workers are not exposed to site groundwater. Most of AOC 512 is covered by vegetation, thus limiting exposure to affected surface soil.



LEGEND

- BELOW 1E-06 RESIDENTIAL RGO
- BETWEEN 1E-05 AND 1E-06 RESIDENTIAL RGO

ND – NOT DETECTED

ALL RESULTS ARE IN μg/kg

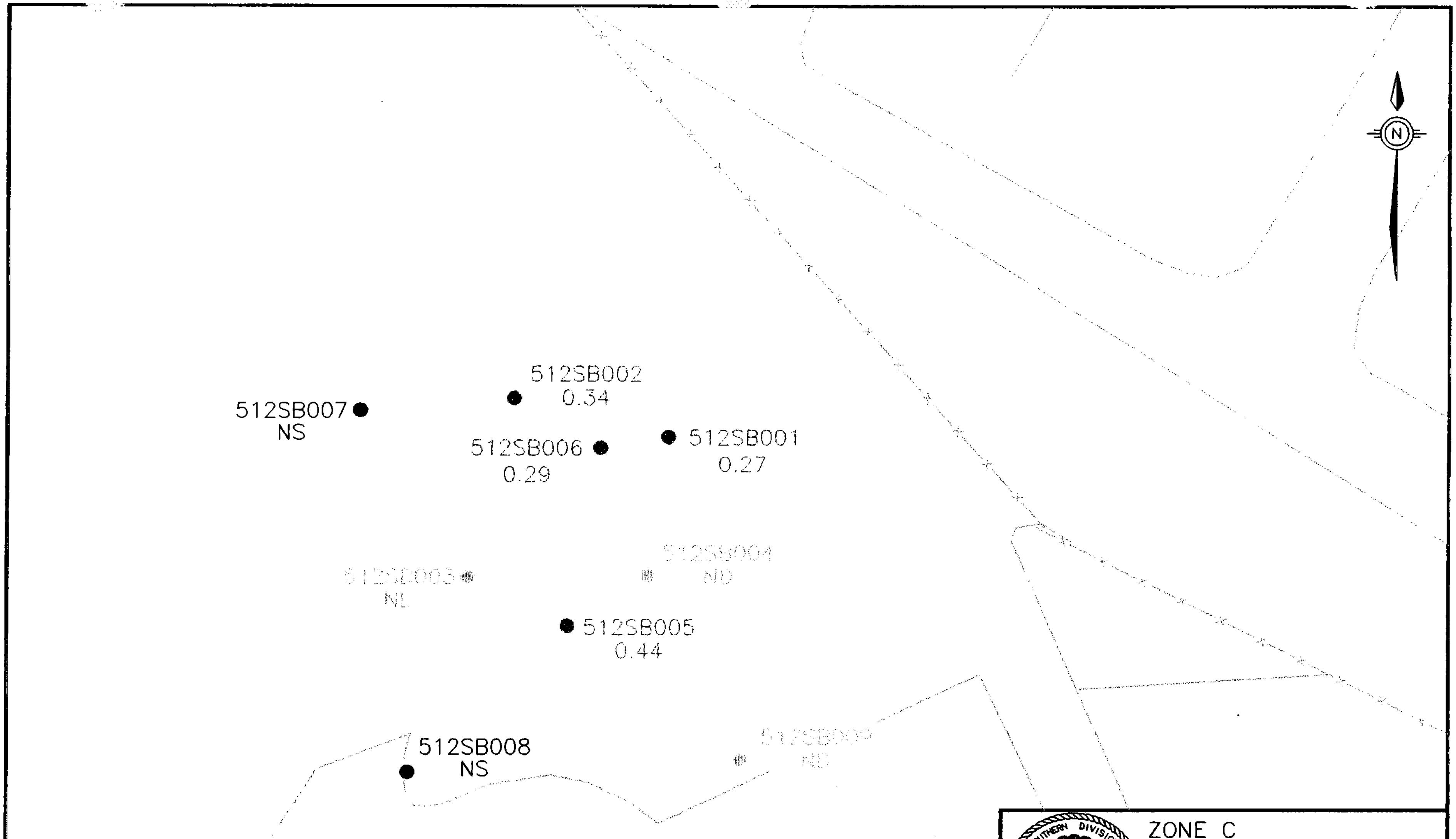
30 0 30

SCALE FEET

ZONE C
RCRA FACILITY
INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 10.6.2.2
AOC #512–FORMER INCINERATOR
BEQs IN SURFACE SOIL

DWG DATE: 10/22/97	DWG NAME: 2903BSS2



LEGEND

- BELOW 1E-06 RESIDENTIAL RGO
- BETWEEN 1E-05 AND 1E-06 RESIDENTIAL RGO

ND – NOT DETECTED

NS – NOT SAMPLED

ALL RESULTS ARE IN mg/kg

30 0 30

SCALE FEET

ZONE C
RCRA FACILITY
INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 10.6.2.3
AOC #512–FORMER INCINERATOR
BERYLLIUM IN SURFACE SOIL

DWG DATE: 10/22/97	DWG NAME: 2903BER3

Current site workers could be infrequently exposed to surface soils during invasive activities such as excavation to repair utilities, etc. However, site workers would not be expected to work onsite in contact with the affected media for eight hours per day, 250 days per year, as assumed in the exposure assessment.

AOC 512 is located in an area currently designated for use as residential and community support, according to base reuse plans. If this area were to be used as a residential site, the vegetative surface would be disturbed, and the surface soil conditions would likely change (i.e., the soils would then be covered with landscaping soil and/or a house). Consequently, exposure to current soil conditions would not be likely under a true residential scenario. These factors indicate that exposure pathways assessed in this human health risk assessment would generally overestimate the risk and hazard posed to current site workers and future site residents.

Determination of Exposure Point Concentrations

No soil UCLs were calculated, because fewer than 10 samples were collected from AOC 512. The maximum concentrations of COPCs were used as the EPCs.

Frequency of Detection and Spatial Distribution

As noted above, BEQs were detected in six of nine surface soil samples collected. The maximum reported concentration for BEQs was 0.17 mg/kg. Since the highest concentrations were near the footprint of the former waste incinerator, it is suspected that the presence of SVOCs in surface soil could be associated with incomplete combustion of waste materials. Beryllium was detected in four of seven surface soil samples, generally within and adjacent to the incinerator footprint. In spite of the detection pattern, it cannot be definitively concluded that beryllium's presence is related to past site operations.

A shallow water table prevented collection of most proposed surface soil samples. As a result, all soil data were evaluated relative to its potential to threaten groundwater. Furthermore, shallow aquifer sampling was performed in the suspected source area. Because soil did not include widespread leaching potential and temporary well data did not identify shallow aquifer impact, soil sampling limitations are not thought to represent a significant source of uncertainty.

Quantification of Risk/Hazard

As indicated by the discussions above, the uncertainty inherent in the risk assessment process is great. In addition, many site-specific factors have affected the uncertainty of this assessment that would upwardly bias the risk and hazard estimates. Exposure pathway-specific sources of uncertainty are discussed below.

Soil

Of the CPSSs screened and eliminated from formal assessment, none was reported at a concentration close to its corresponding RBC. This minimizes the likelihood of potentially significant cumulative risk/hazard based on the eliminated CPSSs. Although the future land use at this site is not definitively known, both the worker and residential exposure scenarios were assessed in this BRA. As previously discussed, these scenarios would likely lead to overestimates of risk and/or hazard.

Central tendency analysis was not formally performed for AOC 512 surface soil, but a simplified approach was taken to assess the potential influences of CT assumptions. The CT assumption for residential exposure duration is 9 years compared to the 30-year assumption for RME. The CT exposure frequency assumption is 234 days/year compared to 350 days/year RME. In addition, the CT ingestion rate assumptions for adults and children are one-half the RME values. Considering the effects of CT estimates of EF, ED, and IR, risk/hazard projections would be approximately one order of magnitude below those, based on the RME. As a result, under the CT assumption, cumulative soil pathway (ingestion and dermal contact) ILCR would fall below the 1E-6 point of departure.

10.6.2.6.7 Risk Summary

The risk and hazard posed by identified soil contaminants were assessed for the hypothetical site worker and the hypothetical future site resident under reasonable maximum exposure assumptions. In surface soils, the incidental ingestion and dermal contact pathways were assessed in this human health risk assessment. Table 10.6.2.15 summarizes risk for each pathway/receptor group evaluated for AOC 512.

10.6.2.6.8 Remedial Goal Options

Soil

Residential soil RGOs are presented in Table 10.6.2.16. No soil RGOs were computed relative to site workers, because no surface soil COCs were identified.

10.6.2.7 Corrective Measures Considerations for AOC 512

For AOC 512, soil and groundwater were investigated. Air, and sediment media were not addressed for this site; therefore, corrective measures are not considered for these media. BaP equivalents and beryllium were identified as the only COC for surface soil. No COCs were identified for groundwater. Potential corrective measures for this COC are indicated in Table 10.6.2.17.

Table 10.6.2.15
Summary of Risk and Hazard for AOC 512
NAVBASE - Charleston Zone C
Charleston, South Carolina

Medium	Exposure Pathway	HI (Adult)	HI (Child)	ILCR (LWA)	HI (Worker)	ILCR (Worker)
Surface Soil	Incidental Ingestion	0.02	0.2	5E-06	0.01	5E-07
	Dermal Contact	0.005	0.02	1E-06	0.003	5E-07
Sum of All Pathways		0.03	0.2	6E-06	0.01	1E-06

Notes:
ND indicates not determined due to the lack of available risk information.
ILCR indicates incremental excess lifetime cancer risk
HI indicates hazard index

Table 10.6.2.16
Residential-Based Remedial Goal Options Surface Soil
AOC 512 Zone C
Naval Base Charleston
Charleston, South Carolina

Chemical	Slope Factor (mg/kg-day)-1	Reference Dose (mg/kg-day)	FI/FC Factor	Unadjusted EPC mg/kg	Hazard-Based Remedial Goal Options 3 mg/kg	1 mg/kg	0.1 mg/kg	Risk-Based Remedial Goal Options 1E-06 mg/kg	1E-05 mg/kg	1E-04 mg/kg	Background Concentration mg/kg
Benzo(a)pyrene Equiv	NA	7.3	1	0.170	ND	ND	ND	0.06	0.6	6	NA
Beryllium	0.005	4.3	1	0.440	ND	ND	ND	0.13	1.3	13	ND

NOTES:

EPC exposure point concentration
NA not applicable
ND not determined
- remedial goal options were based on the residential lifetime weighted average for carcinogens and the child resident for noncarcinogens

Table 10.6.2.17
Potential Corrective Measures

Medium	Compounds	Potential Corrective Measures
Surface Soil	Benzo(a)pyrene equivalents Beryllium	a) No action, monitoring, intrinsic remediation b) Containment/capping c) Excavation, physical and biological treatment d) In-situ, biological treatment

10.6.3 AOC 513 — Former Morgue

AOC 513 operated as a morgue during the early 1920s. Currently, this site is a grass covered area southwest of Building NH-55. The waste disposal practices of this facility are unknown. A CSI was performed at AOC 513 to identify impacts, if any, to site soil resulting from the former morgue operation. The potential contaminants include, alcohol, creosote, and formaldehyde.

10.6.3.1 Soil Sampling and Analysis

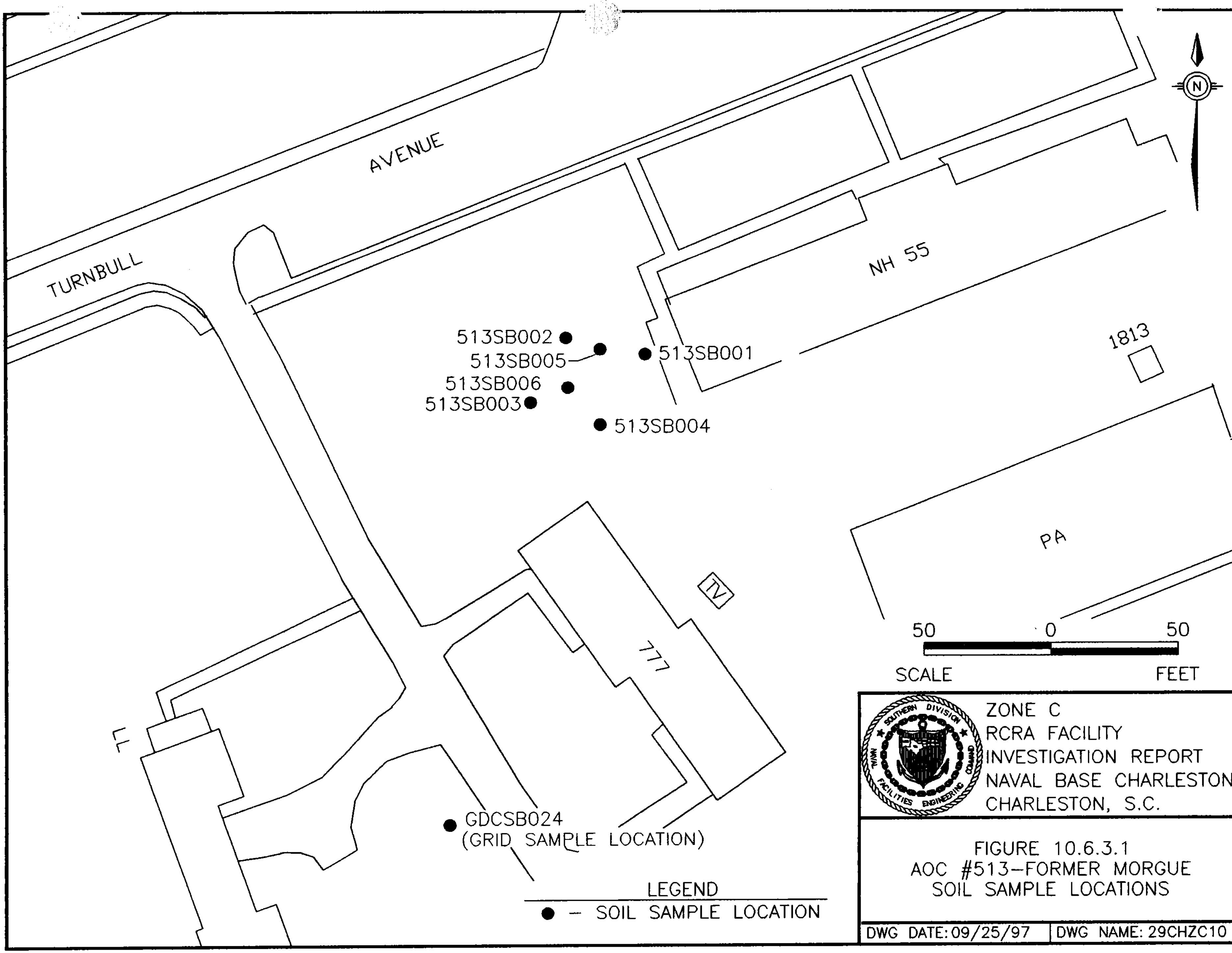
Soil was sampled in accordance with the *Final Zone C RFI Work Plan* (E/A&H, November 1995) and Section 3 of this report. Sample locations were selected following review of historical maps of the area and were placed at locations likely impacted if a release had occurred. Soil sample locations are shown on Figure 10.6.3.1.

Twelve soil samples were collected in one round from six locations (one upper and one lower interval sample per location). Table 10.6.3.1 summarizes the soil sampling and analysis. Soil samples were analyzed for VOCs, SVOCs, pesticides/PCBs, metals, and cyanide at DQO Level III. One duplicate sample was collected and submitted for Appendix IX analyses at DQO Level IV. This includes the parameters listed above as well as herbicides, hexavalent chromium, organophosphorous pesticides, and dioxins.

Soil data were compared to the *USEPA Region III Risk-Based Concentration Table*, June 1996. Results of this preliminary review indicated no additional sampling was warranted at AOC 513.

10.6.3.2 Nature and Extent of Soil Contamination

Soil analytical results for organics are in Table 10.6.3.2, and results for inorganics are in Table 10.6.3.3. Appendix D is a complete analytical report for Zone C and includes the soil analytical results for AOC 513. Appendix H contains detection only summary tables.



ZONE C
RCRA FACILITY
INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 10.6.3.1
AOC #513–FORMER MORGUE
SOIL SAMPLE LOCATIONS

DWG DATE: 09/25/97 | DWG NAME: 29CHZC10

Table 10.6.3.1
Soil Sampling and Analysis Summary
AOC 513 — Former Morgue

Interval	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
Upper	6	6	Standard Suite[a]	Standard Suite[a]	None
Lower	6	6	Standard Suite[a]	Standard Suite[a]	None

Note:
[a] = Standard suite includes VOCs, SVOCs, metals, cyanide, and pesticide/PCBs.

Table 10.6.3.2
Organic Compound Analytical Results for Soil
AOC 513 — Former Morgue

Compound	Sample Interval	Frequency of Detection	Range of Detection	Mean	RBC[a]	Number of Samples Exceeding RBC
Semivolatile Organic Compounds (μg/kg) (Upper Interval — 6 Samples Plus 1 Duplicate/Lower Interval — 6 Samples)						
Benzo(a)anthracene	Upper	2/6	72.0 -150.0	111.0	880[b]	0
Benzo(a)pyrene	Upper	1/6	67.0	67.0	88[b]	0
Benzo(b)fluoranthene	Upper	2/6	120.0 -260.0	190.0	880[b]	0
Benzo(k)fluoranthene	Upper	2/6	150.0 -330.0	240.0	8,800[b]	0
Chrysene	Upper	2/6	74.0 -110.0	92.0	8,800[b]	0
4-Bromophenyl-phenyl ether	Lower	1/6	96.0	96.0	420	0
Di-n-butylphthalate	Upper	5/6	39.0 - 50.0	45.6	780,000	0
	Lower	4/6	38.0 -100.0	66.50	12,000	0
Fluoranthene	Upper	2/6	100.0 -110.0	105.0	310,000	0
Phenanthrene	Upper	1/6	43.0	43.0	230,000	0
Pyrene	Upper	2/6	96.0 - 110.0	103.0	230,000	0
BEQ	Upper	2/6	44.41 - 87.78	66.1	88	0

Table 10.6.3.2
Organic Compound Analytical Results for Soil
AOC 513 — Former Morgue

Compound	Sample Interval	Frequency of Detection	Range of Detection	Mean	RBC[a]	Number of Samples Exceeding RBC
Pesticide and PCB Compounds ($\mu g/kg$) **(Upper Interval — 6 Samples Plus 1 Duplicate / Lower Interval — 6 Samples)**						
Chlordane	Upper	1/6	55.0	55.0	490	0
4,4-DDD	Upper	1/6	4.40	4.40	2,700	0
4,4-DDT	Upper	5/6	5.4 - 20.0	10.620	1,900	0
4,4-DDE	Upper	5/6	4.2 - 37.0	12.440	1,900	0
Dieldrin	Upper	3/6	2.0 - 5.2	3.833	40	0
Delta BHC	Upper	3/6	1.6 - 3.2	2.167	NA	0
Endrin	Upper	5/6	4.0 - 17.0	9.880	2,300	0
Endrin aldehyde	Upper	4/6	1.3 - 2.3	1.825	2,300	0
Endosulfan I	Upper	2/6	1.8 - 3.7	2.75	47,000	0
Endosulfan sulfate	Upper	3/6	2.9 - 3.5	2.77	47,000	0
Heptachlor epoxide	Upper	2/6	3.4 - 16.0	9.7	70	0
Other Organic Compounds						
Herbicide Compounds ($\mu g/kg$) **(Lower Interval — 1 Sample)**						
Dinoseb	Lower	1/1	2.3	NA	45,000	0
Organophosphorous Pesticides ($\mu g/kg$) **(Lower Interval — 1 Sample)**						
Disulfoton	Lower	1/1	5.5	NA	2.6	1
Dioxins in Soil (ng/kg) **(Lower Interval — 1 Sample)**						
1234678-HpCDD	Lower	1/1	0.34	NA	NA	NA
1234678-HpCDF	Lower	1/1	8.83	NA	NA	NA
123478-HxCDF	Lower	1/1	1.57	NA	NA	NA
1234789-HpCDF	Lower	1/1	0.20	NA	NA	NA
123678-HxCDF	Lower	1/1	0.37	NA	NA	NA
123789-HxCDF	Lower	1/1	0.32	NA	NA	NA

Table 10.6.3.2
Organic Compound Analytical Results for Soil
AOC 513 — Former Morgue

Compound	Sample Interval	Frequency of Detection	Range of Detection	Mean	RBC[a]	Number of Samples Exceeding RBC
234678-HxCDF	Lower	1/1	0.17	NA	NA	NA
OCDD	Lower	1/1	0.88	NA	NA	NA
OCDF	Lower	1/1	27.68	NA	NA	NA
TEQ	Lower	1/1	0.38	NA	1,000	0

Notes:
[a] = Noncarcinogenic RBCs were adjusted to equate to a hazard quotient of 0.1.
[b] = These compounds are cPAHs and were multiplied by the appropriate BEF for comparison as BEQs.
All results are in μg/kg except dioxin which is in ng/kg.

Table 10.6.3.3
Inorganic Analytical Results for Soil
AOC 513 — Former Morgue

Compound	Sample Interval	Frequency of Detection[a]	Range of Detection (mg/kg)	Mean (mg/kg)	Reference Conc. (mg/kg)	Number of Samples Exceeding Reference
Aluminum	Upper	6/6	3,970 - 4,510	4,238.33	9,990	0
	Lower	6/6	2320 - 3900	3,226.67	23,700	0
Antimony	Upper	3/6	0.220 - 0.41	0.30	0.55	0
Arsenic	Upper	6/6	0.470 - 1.50	0.72	14.2	0
Barium	Upper	6/6	9.8 - 19.1	15.50	77.2	0
	Lower	6/6	2.7 - 15.95	10.14	68.5	0
Calcium	Upper	6/6	224 - 1,480	583.33	NA	0
	Lower	6/6	70.6 - 233.0	114.30	NA	0
Chromium	Upper	6/6	4.3 - 5.1	4.50	26.4	0
	Lower	6/6	3.5 - 5.10	4.18	12.5	0
Cobalt	Upper	6/6	0.31 - 0.39	0.34	3.22	0
	Lower	5/6	0.46 - 0.56	0.50	7.1	0
Copper	Upper	6/6	1.2 - 4.7	2.77	34.7	0
	Lower	6/6	0.34 - 1.20	0.80	42.2	0

Table 10.6.3.3
Inorganic Analytical Results for Soil
AOC 513 — Former Morgue

Compound	Sample Interval	Frequency of Detection[a]	Range of Detection (mg/kg)	Mean (mg/kg)	Reference Conc. (mg/kg)	Number of Samples Exceeding Reference
Iron	Upper	6/6	2,270 - 2,590	2,441.67	NA	0
	Lower	6/6	1,100 - 3,210	2,415.00	NA	0
Lead	Upper	6/6	13.2 - 120.0	48.12	330	0
	Lower	6/6	1.6 - 4.0	2.73	73.2	0
Magnesium	Upper	6/6	125.0 - 164.0	139.00	NA	0
	Lower	6/6	103.0 - 225.5	166.75	NA	0
Manganese	Upper	6/6	15.1 - 33.5	24.62	92.5	0
	Lower	6/6	3.5 - 23.7	14.47	106	0
Nickel	Upper	6/6	1.1 - 1.4	1.25	12.3	0
	Lower	6/6	0.91 - 1.50	1.22	16.7	0
Potassium	Upper	6/6	51.1 - 81.0	67.87	NA	0
	Lower	6/6	55.9 - 105.0	77.50	NA	0
Selenium	Upper	5/6	0.51 - 0.93	0.76	1.44	0
	Lower	4/6	0.50 - 0.59	0.56	2.90	0
Tin	Upper	6/6	1.0 - 2.0	1.57	2.95	0
	Lower	6/6	0.9 - 1.7	1.36	2.37	0
Vanadium	Upper	6/6	3.1 - 4.1	3.55	23.4	0
	Lower	6/6	1.7 - 5.0	3.50	56.9	0
Zinc	Upper	6/6	8.0 - 42.6	18.40	159	0
	Lower	6/6	1.9 - 5.6	4.17	243	0

Volatile Organic Compounds in Soil

No VOCs were detected in soil samples collected at AOC 513.

Semivolatile Organic Compounds in Soil

Ten SVOCs were detected in soil samples from AOC 513; most were in 513SB00301 and 513SB00601. However, all SVOCs were detected below their respective RBCs and SSLs. Five of the compounds detected are cPAHs. The BEQs calculated for AOC 513 soil show no exceedances of the benzo(a)pyrene RBC of 88 μg/kg.

Pesticides and PCBs in Soil

Eleven pesticide compounds were detected in surface soil samples from AOC 513; however, all were below their respective RBCs. Subsurface soil samples were below their SSLs. No PCB compounds were detected in soil samples from AOC 513.

Other Compounds in Soil

Other compounds include the Appendix IX compound groups that are not part of the standard analytical suite, including: herbicides, organophosphorous pesticides, hexavalent chromium, and dioxins.

One herbicide, dinoseb, was detected in soil, but it was below its SSL of 45,000 μg/kg. One organophosphorous pesticide compound, disulfoton, was detected above its SSL of 2.6 μg/kg at 5.5 μg/kg.

Nine dioxins were detected in the duplicate sample submitted for analysis. The TEQ calculated for this sample was 0.38 ng/kg, which is below the TDCC RBC of 1,000 ng/kg.

Inorganic Elements in Soil

Table 10.6.3.3 summarizes the inorganic analytical results for soil samples from AOC 513. Eighteen analytes were detected in upper interval samples, and 16 were detected in lower interval samples. All were detected below their respective reference concentrations.

No cyanide was detected in soil samples from AOC 513. No hexavalent chromium was detected in the duplicate soil samples submitted for analysis.

10.6.3.3 Fate and Transport Assessment

AOC 513, formerly a morgue, is currently a grassy area adjacent to Building NH-55. Environmental media sampled as part of the RFI at AOC 513 include surface soil and subsurface soil. Potential migration pathways for AOC 513 include constituents leaching from soil-to-groundwater and emission of volatile constituents from surface soil to air.

10.6.3.3.1 Soil-to-Groundwater Cross Media Transport

Table 10.6.3.4 compares maximum detected concentrations of chemicals in AOC 513 soil to the greater of risk-based soil screening levels considered protective of groundwater or background reference concentrations. No groundwater was sampled as part of the AOC 513 RFI. As a result, no qualitative screening was performed. Three constituents (delta-BHC, dieldrin, and disulfoton) were detected in AOC 513 soil marginally above groundwater protection SSLs. Delta-BHC and dieldrin were detected in surface soil but not in subsurface soil. This indicates soil concentrations of delta-BHC and dieldrin are protective of the shallow aquifer. Disulfoton was detected in one subsurface soil sample above its groundwater protection SSL. This indicates the potential for limited soil to groundwater migration of disulfoton; however, the single detection does not represent a widespread threat to the AOC 513 shallow aquifer is not expected.

10.6.3.3.2 Soil-to-Air Cross-Media Transport

No volatile organic compounds were detected in AOC 513 surface soil. As a result, the soil-to-air migration pathway is not significant at this site.

Table 10.6.3.4
Chemicals Detected in Surface Soil and Subsurface Soil
Comparison to Groundwater Protection SSLs and Background UTLs
NAVBASE-Charleston, Zone C, AOC 513
Charleston, South Carolina

Parameter	Surface Soil Maximum Conc.	Subsurfac Soil Maximum Conc.	Ground Water Protection SSL or UTL *	Soil Units	Soil Conc. Exceeds SSL or UTL
Aluminum	4510	3900	23700	MG/KG	NO
Antimony	0.41	ND	0.55	MG/KG	NO
Arsenic	1.5	ND	29	MG/KG	NO
Barium	19.1	15.95	1600	MG/KG	NO
Benzo(a)pyrene Equivalents					
Benzo(a)pyrene	67	ND	8000	UG/KG	NO
Benzo(a)anthracene	150	ND	2000	UG/KG	NO
Benzo(b)fluoranthene	260	ND	5000	UG/KG	NO
Benzo(k)fluoranthene	330	ND	49000	UG/KG	NO
Chrysene	110	ND	160000	UG/KG	NO
delta-BHC	3.2	ND	3	UG/KG	YES
4-Bromophenyl-phenylether	ND	96	840	UG/KG	NO
Chlordane	55	ND	10000	UG/KG	NO
Chromium	5.1	5.1	38	MG/KG	NO
Cobalt	0.39	0.56	7.1	MG/KG	NO
Copper	4.7	1.2	42.2	MG/KG	NO
4,4'-DDD	4.4	ND	16000	UG/KG	NO
4,4'-DDE	37	ND	54000	UG/KG	NO
4,4'-DDT	20	ND	32000	UG/KG	NO
Di-n-butylphthalate	50	100	2300000	UG/KG	NO
Dieldrin	5.2	ND	4	UG/KG	YES
Dinoseb	ND	2.3	170	UG/KG	NO
Dioxin (TCDD TEQ)	ND	0.38	4000	PG/G	NO
Disulfoton	ND	5.5	5	UG/KG	YES
Endosulfan	5.3	ND	1800	UG/KG	NO
Endrin	17	ND	1000	UG/KG	NO
Endrin aldehyde	2.3	ND	1000	UG/KG	NO
Fluoranthene	110	ND	430000	UG/KG	NO
Heptachlor	16	ND	23000	UG/KG	NO
Lead	120	4	330	MG/KG	NO
Manganese	33.5	23.7	106	MG/KG	NO
Nickel	1.4	1.5	130	MG/KG	NO
Phenanthrene	43	ND	100000000	UG/KG	NO
Pyrene	110	ND	420000	UG/KG	NO
Selenium	0.93	0.59	5	MG/KG	NO
Tin	2	1.7	2.95	MG/KG	NO
Vanadium	4.1	5.05	600	MG/KG	NO
Zinc	42.6	5.6	1200	MG/KG	NO

* - See Table 6-2
NA - Not available
ND - Not detected
SSL - Groundwater protection soil screening level
UTL - Grid-based background upper tolerance limit
MG/KG - Milligram per kilogram
UG/KG - Micrograms per kilogram

10.6.3.4 Human Health Risk Assessment

10.6.3.4.1 Site Background and Investigative Approach

The purpose of the investigation at AOC 513 was the assessment of soil potentially affected by past site activities. AOC 513 is the site of a former morgue which operated at this location in the early 1920s. The waste disposal activities of this facility are unknown. Currently, the site is a grassy area southwest of Building NH-55.

Six upper interval soil samples were collected at AOC 513. Table 10.6.3.5 lists the analytical methods used for the corresponding samples.

10.6.3.4.2 COPC Identification

Soil

Surface soil data and screening values used in the screening comparison for AOC 513 soil are summarized in Table 10.6.3.6. As shown in the tables, no COPCs were identified as a result of comparisons to risk-based and reference standards. In addition, no COPCs were identified based on the results of Wilcoxon rank sum test analyses. Therefore, no formal assessment of upper interval soil was warranted.

10.6.3.5 Corrective Measures Considerations

No further action is required based on the analytical results and risk assessment. No COCs were identified.

Table 10.6.3.5
Methods Run at AOC 513
Surface Soil

Site	Location	Metal	SVOA	VOA	Cn	Hexa	Diox	Oppe	Herb	Pest	Tph	Otin	Eng
513	B001	Y	Y	Y	Y					Y			
513	B002	Y	Y	Y	Y					Y			
513	B003	Y	Y	Y	Y					Y			
513	B004	Y	Y	Y	Y					Y			
513	B005	Y	Y	Y	Y					Y			
513	B006	Y	Y	Y	Y					Y			

METHODS:

Metal: TAL (Target Analyte List) Metals plus tin:
Methods: 6000/7000 Series
VOA: Volatile Organic Analysis: Method 8240
SVOA: Semi-volatile Organic Analysis: Method 8270
Cn: Cyanide (Soil: Method 9010, Water: Method 9012)
Hexa: Hexavalent Chromium: Method 7195
Diox: Dioxins

Oppe: Organophosphate Pesticides:
Method 8140
Herb: Chlorinated Herbicides: Method 8150
Pest: Chlorinated Pesticides: Method 8080
Tph: Total Petroleum Hydrocarbons
Otin: Organotin
Eng: Engineering Parameters

KEY:

Y: Analyzed for standard list
D: Duplicate Analysis
IR: Method 4181
DR: Extraction Method 3550, GC Method 8100
GR: Extraction Method 5030, GC Method 8015
Blank value indicates this method of analysis was not performed

Table 10.6.3.6
Summary of Chemicals Present in Site Samples, AOC 513
Surface Soil
NAVBASE - Charleston, Zone C
Charleston, South Carolina

NAME	CONC UNITS	FREQ	DETECTS Min	DETECTS Max	DETECTS Avg	SCREENING Value	SCREENING # Over	Source	NON-DETECTS Min	NON-DETECTS Max	BACKGROUND Value	BACKGROUND # Over
Carcinogenic PAHs												
B(a)P Equiv.	UG/KG	2 - 6	44.41	87.774	66.09	88			1368.17	1438.5		
Benzo(a)anthracene	UG/KG	2 - 6	72	150	111.00	880		C	700	740		
Benzo(b)fluoranthene	UG/KG	2 - 6	120	260	190.00	880		C	820	860		
Chrysene	UG/KG	2 - 6	74	110	92.00	88000		C	570	600		
Benzo(k)fluoranthene	UG/KG	2 - 6	150	330	240.00	8800		C	660	690		
Benzo(a)pyrene	UG/KG	1 - 6	67	67	67.00	88		C	700	740		
Inorganics												
Aluminum (Al)	MG/KG	6 - 6	3970	4510	4238.33	7800		N			9990	
Antimony (Sb)	MG/KG	3 - 6	0.22	0.41	0.30	3.1		N	0.2	0.21	0.55	
Arsenic (As)	MG/KG	6 - 6	0.47	1.5	0.72	0.43	6	C			14.2	
Barium (Ba)	MG/KG	6 - 6	9.8	19.1	15.50	550		N			77.2	
Calcium (Ca)	MG/KG	6 - 6	224	1480	583.33	NA						
Chromium (Cr)	MG/KG	6 - 6	4.3	5.1	4.50	39		N			26.4	
Cobalt (Co)	MG/KG	6 - 6	0.31	0.39	0.34	470		N			3.22	
Copper (Cu)	MG/KG	6 - 6	1.2	4.7	2.77	310		N			34.7	
Iron (Fe)	MG/KG	6 - 6	2270	2590	2441.67	NA		N				
Lead (Pb)	MG/KG	6 - 6	13.2	120	48.12	400		j			330	
Magnesium (Mg)	MG/KG	6 - 6	125	164	139.00	NA						
Manganese (Mn)	MG/KG	6 - 6	15.1	33.5	24.62	180		N			92.5	
Nickel (Ni)	MG/KG	6 - 6	1.1	1.4	1.25	160		N			12.3	
Potassium (K)	MG/KG	6 - 6	51.1	81	67.87	NA						
Selenium (Se)	MG/KG	5 - 6	0.51	0.93	0.76	39		N	0.48	0.48	1.44	
Tin (Sn)	MG/KG	6 - 6	1	2	1.57	4700					2.95	
Vanadium (V)	MG/KG	6 - 6	3.1	4.1	3.55	55		N			23.4	
Zinc (Zn)	MG/KG	6 - 6	8	42.6	18.40	2300		N			159	
Chlorinated Pesticides												
delta-BHC	UG/KG	3 - 6	1.6	3.2	2.17	100		I	1.1	1.1		
Chlordane	UG/KG	1 - 6	55	55	55.00	490		C	4.2	4.4		
4,4'-DDD	UG/KG	1 - 6	4.4	4.4	4.40	2700		C	3.7	3.7		

Table 10.6.3.6
Summary of Chemicals Present in Site Samples, AOC 513
Surface Soil
NAVBASE - Charleston, Zone C
Charleston, South Carolina

NAME	CONC UNITS	FREQ	DETECTS Min	DETECTS Max	DETECTS Avg	SCREENING Value	SCREENING # Over	Source	NON-DETECTS Min	NON-DETECTS Max	BACKGROUND Value	BACKGROUND # Over
4,4'-DDE	UG/KG	5 - 6	4.2	37	12.44	1900		C	3.7	3.7		
4,4'-DDT	UG/KG	5 - 6	5.4	20	10.62	1900		C	3.7	3.7		
Dieldrin	UG/KG	3 - 6	2	5.2	3.83	40		C	1.6	1.6		
Endosulfan I	UG/KG	2 - 6	1.8	3.7	2.75	47000		N	1.6	1.6		
Endosulfan sulfate	UG/KG	3 - 6	2.4	3.5	2.77	47000		N	2.1	2.1		
Endrin	UG/KG	5 - 6	4	17	9.88	2300		N	2.6	2.6		
Endrin aldehyde	UG/KG	4 - 6	1.3	2.3	1.83	2300		h	1.1	1.1		
Heptachlor epoxide	UG/KG	2 - 6	3.4	16	9.70	70		C	1.1	1.1		
Semivolatile Organics												
Di-n-butylphthalate	UG/KG	5 - 6	39	50	45.60	780000		N	840	840		
Fluoranthene	UG/KG	2 - 6	100	110	105.00	310000		N	980	1000		
Phenanthrene	UG/KG	1 - 6	43	43	43.00	310000		f	660	690		
Pyrene	UG/KG	2 - 6	96	110	103.00	230000		N	780	810		

Notes:
- * Retained as a chemical of potential concern
- C The RBC is based on carcinogenic effects
- N The RBC is based on noncarcinogenic effects
- j Screening level is set equal to the soil action level
- l The RBC for gamma-BHC is used as a surrogate
- h The RBC for endrin is used as a surrogate
- f The RBC for fluoranthene is used as a surrogate

10.6.4 AOC 517 — Former Firing Range

AOC 517, Building M-192, was an indoor firing range from 1959 until 1974. Currently, the building serves as a classroom and an equipment storage area. A CSI was performed at AOC 517 where soil and wipe samples were collected to identify impacts to soil and building material surfaces resulting from the former firing range operations. Potential contaminants include lead and other metals.

10.6.4.1 Soil Sampling and Analysis

Soil sampling was conducted in accordance with the *Final Zone C Work Plan* (E/A&H, November 1995) and as outlined in Section 3 of this report. Sampling locations were selected following review of historical maps of the area and placed at locations most likely impacted if a release had occurred. Figure 10.6.4.1 shows soil sample locations.

Soil was sampled in one round at AOC 517, where 10 soil samples were collected from five locations (one upper interval and one lower interval soil sample per location). Samples were analyzed for VOCs, SVOCs, pesticides/PCBs, metals, and cyanide at DQO Level III. One duplicate sample was collected and submitted for Appendix IX analyses at DQO Level IV. This includes the parameters listed above as well as herbicides, hexavalent chromium, organophosphorous pesticides, and dioxins. Table 10.6.4.1 summarizes the soil sampling and analysis.

Table 10.6.4.1
Soil Sampling and Analysis Summary
AOC 517 — Former Firing Range

Interval	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
Upper	5	5	Standard Suite[a]	Standard Suite[a]	None
Lower	5	5	Standard Suite[a]	Standard Suite[a]	None

Note:
[a] = Standard Suite includes VOCs, SVOCs, metals, cyanide, and pesticides/PCBs.

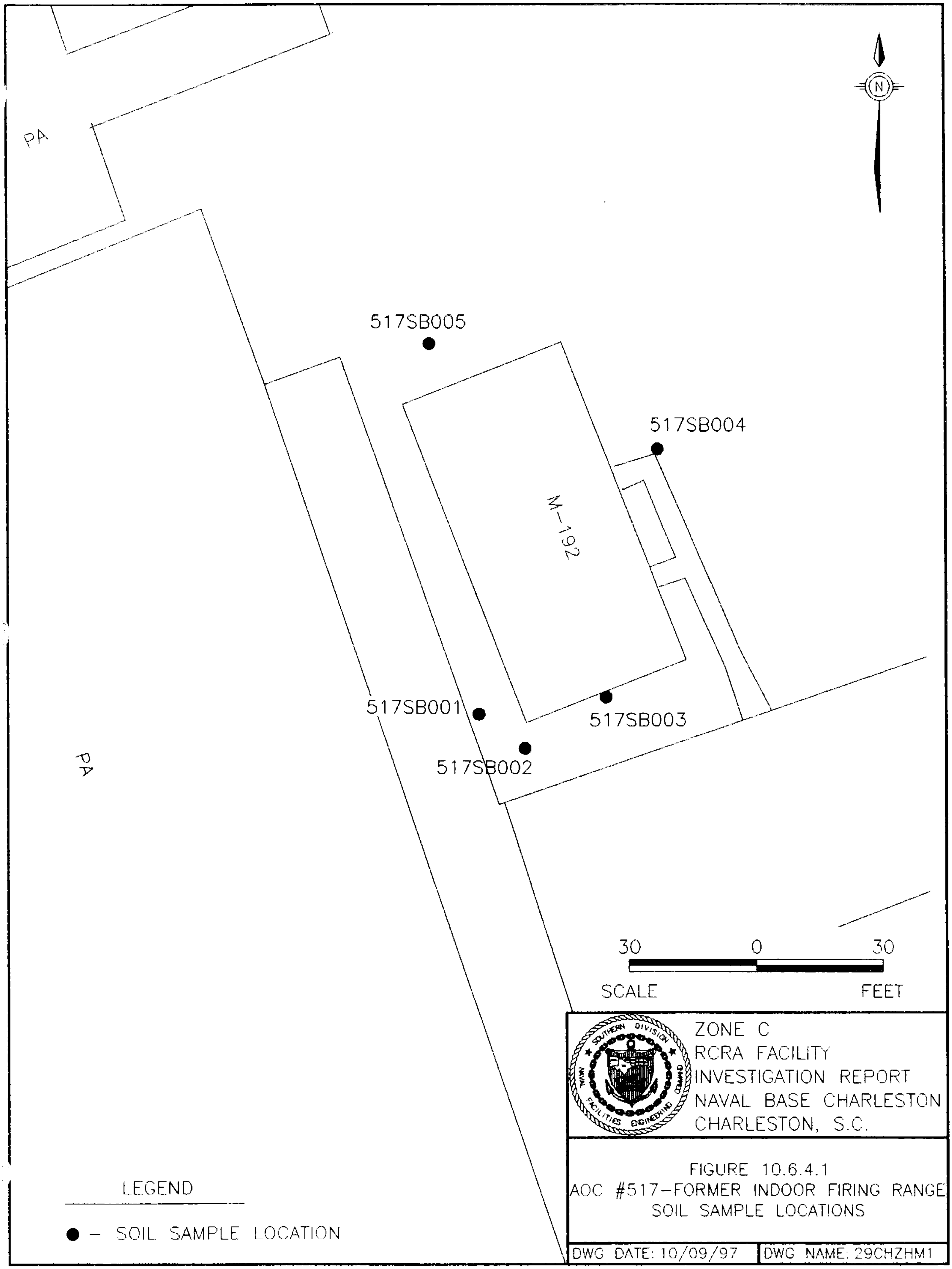


FIGURE 10.6.4.1
AOC #517–FORMER INDOOR FIRING RANGE
SOIL SAMPLE LOCATIONS

Soil data were compared to the USEPA Region III *Risk-Based Concentration Table*; June 1996. This preliminary review indicated that additional sampling was not warranted at AOC 517.

10.6.4.2 Nature and Extent of Contamination

Soil analytical results for organics are in Table 10.6.4.2, and results for inorganics are in Table 10.6.4.3. Appendix D is a complete analytical report for Zone C, including AOC 517. Appendix H contains detection only summary tables.

Table 10.6.4.2
Organic Compound Analytical Results for Soil
AOC 517 — Former Firing Range

Compound	Sample Interval	Frequency of Detection	Range of Detection	Mean	RBC[a]	Number of Samples Exceeding RBC
Volatile Organic Compounds (μg/kg) (Upper Interval — 5 Samples / Lower Interval — 5 Samples plus 1 Duplicate)						
Acetone	Upper	1/5	28.0	NA	780,000	0
Semivolatile Organic Compounds (μg/kg) (Upper Interval — 5 Samples / Lower Interval — 5 Samples plus 1 Duplicate)						
Butylbenzylphthalate	Upper	1/5	720.0	NA	1,600,000	0
	Lower	1/5	180.0	NA	6,800	0
bis(2-Ethylhexyl)phthalate	Upper	2/5	74.0 - 540.0	307.0	46,000	0
	Lower	1/5	133.5	NA	11,000	0
Di-n-butylphthalate	Upper	5/5	49.0 - 89.0	65.8	180,000	0
	Lower	5/5	39.0 - 110.0	81.6	12,000	0
Pesticide and PCB Compounds (μg/kg) (Upper Interval — 5 Samples / Lower Interval — 5 Samples plus 1 Duplicate)						
4,4'-DDE	Upper	3/5	5.2 - 9.8	7.5	7,900	0
Endosulfan I	Upper	1/5	2.2	NA	47,000	0
Endosulfan sulfate	Upper	3/5	2.6 - 3.2	2.9	47,000	0
Endrin aldehyde	Upper	2/5	1.2 - 1.6	1.4	230,000	0
Aroclor-1260	Upper	1/5	79.0	NA	83	0

Table 10.6.4.2
Organic Compound Analytical Results for Soil
AOC 517 — Former Firing Range

Compound	Sample Interval	Frequency of Detection	Range of Detection	Mean	RBC[a]	Number of Samples Exceeding RBC
Herbicide Compounds (μg/kg) (Lower Interval 1 Duplicate Sample)						
2,4-Dichlorophenoxyacetic acid	Lower	1/1	23.0	NA	1,700	0
Dioxin Compounds in Soil (ng/kg) (Lower Interval — 1 Duplicate Sample)						
1234678-HpCDD	Lower	1/1	7.31	NA	NA	0
1234678-HpCDF	Lower	1/1	7.63	NA	NA	0
123478-HxCDF	Lower	1/1	0.36	NA	NA	0
123678-HxCDF	Lower	1/1	0.54	NA	NA	0
123789-HxCDF	Lower	1/1	0.45	NA	NA	0
234678-HxCDF	Lower	1/1	0.26	NA	NA	0
OCDD	Lower	1/1	92.45	NA	NA	0
OCDF	Lower	1/1	14.37	NA	NA	0
TEQ	Lower	1/1	41.6	NA	1,000	0

Notes:
a = Noncarcinogenic RBCs were adjusted to equate to a hazard quotient of 0.1.
b = These compounds are cPAHs and were multiplied by the appropriate BEF for comparison as BEQs.
All results are in micrograms per kilogram (μg/kg) except for dioxins which are in nanograms per kilogram (ng/kg).

Table 10.6.4.3
Inorganic Analytical Results for Soil
AOC 517 — Former Firing Range
(Upper Interval — 5 Samples / Lower Interval — 5 Samples plus 1 Duplicate)

Analyte	Sample Interval	Frequency of Detection[a]	Range of Detection (mg/kg)	Mean (mg/kg)	Reference Conc. (mg/kg)	Number of Samples Exceeding Reference
Antimony	Upper	3/5	0.41 - 0.55	0.467	0.55	1
Aluminum	Upper	5/5	3,450 - 6,620	5,530	9,990	0
	Lower	5/5	4,150 - 5,880	4,999	23,700	0
Arsenic	Upper	5/5	0.59 - 1.90	1.26	14.2	0
	Lower	2/5	0.380 - 0.390	0.385	14.1	0
Barium	Upper	5/5	10.6 - 18.6	15.3	77.2	0
	Lower	5/5	3.4 - 15.5	9.19	68.5	0
Calcium	Upper	5/5	185.0 - 9,770	3,973	NA	NA
	Lower	4/5	49.3 - 13,970	4,412	NA	NA
Chromium	Upper	5/5	5.3 - 10.1	6.54	26.4	0
	Lower	5/5	4.7 - 5.6	5.2	12.5	0
Cobalt	Upper	5/5	0.54 - 1.6	0.79	3.22	0
	Lower	5/5	0.42 - 0.72	0.56	7.1	0
Copper	Upper	5/5	1.6 - 19.4	6.64	34.7	0
	Lower	3/5	1.1 - 2.1	1.5	42.2	0
Iron	Upper	5/5	1,760 - 3,040	2,416	NA	NA
	Lower	5/5	727 - 2,640	1,608	NA	NA
Lead	Upper	5/5	7.3 - 194.0	77.4	330	0
	Lower	5/5	2.5 - 17.4	7.23	73.2	0
Magnesium	Upper	5/5	247.0 - 320.0	272.6	NA	NA
	Lower	5/5	116.0 - 341.0	215.3	NA	NA

Table 10.6.4.3
Inorganic Analytical Results for Soil
AOC 517 — Former Firing Range
(Upper Interval — 5 Samples / Lower Interval — 5 Samples plus 1 Duplicate)

Analyte	Sample Interval	Frequency of Detection[a]	Range of Detection (mg/kg)	Mean (mg/kg)	Reference Conc. (mg/kg)	Number of Samples Exceeding Reference
Manganese	Upper	5/5	15.3 - 27.3	20.4	92.5	0
	Lower	5/5	4.2 - 22.4	13.1	106	0
Mercury	Upper	1/5	0.16	NA	0.24	0
Nickel	Upper	5/5	2.3 - 4.8	3.0	12.3	0
	Lower	2/5	1.9 - 2.1	2.0	16.7	0
Potassium	Upper	5/5	104.0 - 172.0	138.8	NA	NA
	Lower	5/5	72.9 - 186.0	117.2	NA	NA
Selenium	Upper	1/5	0.58	NA	1.44	0
Tin	Upper	5/5	0.790 - 3.300	1.9	2.95	1
	Lower	5/5	0.830 - 1.400	1.21	2.37	0
Vanadium	Upper	5/5	4.4 - 6.9	5.2	23.4	0
	Lower	5/5	1.4 - 4.9	2.91	56.9	0
Zinc	Upper	5/5	9.5 - 106.0	46.8	159	0
	Lower	5/5	2.8 - 16.8	8.0	243	0

Volatile Organic Compounds in Soil

Acetone was the only VOC detected, but was its RBC of 780,000 μg/kg.

Semivolatile Organic Compounds in Soil

Three SVOCs were detected in soil samples: butylbenzylphthalate, bis(2-ethylhexyl)phthalate, and di-n-butylphthalate. All were detected below their respective RBCs and SSLs. No cPAHs were detected in AOC 517 soil samples.

Pesticides and PCBs in Soil

Four pesticide compounds were detected in soil samples: 4-4'-DDE, endosulfan I, endosulfan sulfate, and endrin aldehyde. All were detected below their respective RBCs. Pesticides were not detected in the lower interval soil samples. Aroclor-1260 was the only PCB detected, but it is below its RBC of 83 μg/kg.

Other Organic Compounds in Soil

Other organic compounds include the Appendix IX compound groups that are not part of the standard analytical suite including: herbicides, organophosphorous pesticides, and dioxins.

One herbicide compound, 2,4-dichlorophenoxyacetic acid (2,4-D), was detected in the duplicate sample. It was below its SSL of 1,700 μg/kg. No organophosphorous pesticide compounds were detected in the duplicate soil samples submitted for Appendix IX analysis.

Eight dioxins were detected in the duplicate sample from AOC 517. No RBCs apply to these parameters. The TEQ was calculated for this sample at 41.6 ng/kg, which is below the 2,3,7,8-TCDD RBC of 1,000 ng/kg.

Inorganic Elements in Soil

Table 10.6.4.3 summarizes the inorganic analytical results for AOC 517. Nineteen inorganics were detected in upper interval soil samples, and 16 were detected in lower interval soil samples. One inorganic, tin, was detected above its reference concentration for the upper interval. Tin was detected in all upper interval samples with a range of 0.79 to 3.3 mg/kg and a mean of 1.9 mg/kg. One sample (517SB001, 3.30 mg/kg) exceeded the tin reference concentration of 2.95 mg/kg. Antimony was equal to its reference concentration (0.55 mg/kg) at one location 517SB002.

Cyanide was not detected in soil samples from AOC 517. Hexavalent chromium was not detected in soil samples from AOC 517.

10.6.4.3 Wipe Sampling and Analysis

Wipe sampling was conducted in accordance with the *Final Zone C Work Plan*, (E/A&H, November 1995) and Section 3 of this report. Seven wipe samples were collected within Building M-192 from a lead pipe and submitted for analysis for lead only.

10.6.4.4 Wipe Sample Results

Lead was detected in the wipe samples ranging from 55 $\mu g/100\ cm^2$ to 21,500 $\mu g/100\ cm^2$ with a mean of 4,394 $\mu g/100\ cm^2$.

10.6.4.5 Fate and Transport Assessment

AOC 517, a former indoor firing range, currently serves as a classroom and equipment storage area. Migration pathways investigated for AOC 517 include soil to groundwater and emission of volatile constituents from surface soil to air. Environmental media sampled as part of the AOC 517 RFI include surface soil and subsurface soil.

10.6.4.5.1 Soil to Groundwater Cross Media Transport

Table 10.6.4.4 compares maximum detected concentrations of chemicals in AOC 517 soil to the greater of risk-based soil screening levels considered protective of groundwater or background reference concentrations. The marginal exceedances and limited area of impact indicate that AOC 517 soil is protective of the shallow aquifer.

Table 10.6.4.4
Chemicals Detected in Surface Soil and Subsurface Soil
Comparison to Groundwater Protection SSLs and Background UTLs
NAVBASE-Charleston, Zone C, AOC 517
Charleston, South Carolina

Parameter	Surface Soil Maximum Conc.	Subsurface Soil Maximum Conc.	Ground Water Protection SSL or UTL *	Soil Units	Soil Conc. Exceeds SSL or UTL
Acetone	28	ND	1600	UG/KG	NO
Aluminum	6620	5880	23700	MG/KG	NO
Antimony	0.55	ND	0.55	MG/KG	NO
Aroclor-1260	79	ND	16000	UG/KG	NO
Arsenic	1.9	0.39	29	MG/KG	NO
Barium	18.6	15.5	1600	MG/KG	NO
Butylbenzylphthalate	720	180	930000	UG/KG	NO
Chromium	10.1	5.6	38	MG/KG	NO
Cobalt	1.6	0.72	7.1	MG/KG	NO
Copper	19.4	2.1	42.2	MG/KG	NO
2,4-D	ND	23	1880	UG/KG	NO
4,4'-DDE	9.8	ND	54000	UG/KG	NO
Di-n-butylphthalate	89	110	2300000	UG/KG	NO
Dioxin (TCDD TEQ)	ND	0.415	4000	PG/G	NO
Endosulfan	3.2	ND	1800	UG/KG	NO
Endrin aldehyde	1.6	ND	1000	UG/KG	NO
bis(2-Ethylhexyl)phthalate	540	133.5	3600000	UG/KG	NO
Lead	194	17.4	330	MG/KG	NO
Manganese	27.3	22.4	106	MG/KG	NO
Mercury	1.6	ND	0.3	MG/KG	YES
Nickel	4.8	2.1	130	MG/KG	NO
Selenium	0.58	ND	5	MG/KG	NO
Tin	3.3	1.4	2.95	MG/KG	YES
Vanadium	6.9	4.9	600	MG/KG	NO
Zinc	106	16.8	1200	MG/KG	NO

* - See Table 6-2
NA - Not available
ND - Not detected
SSL - Groundwater protection soil screening level
UTL - Grid-based background upper tolerance limit
MG/KG - Milligram per kilogram
UG/KG - Micrograms per kilogram

10.6.4.5.2 Soil-to-Air Cross-Media Transport

Table 10.6.4.5 lists the volatile organic compounds detected in surface soil samples collected at AOC 517 along with corresponding soil-to-air volatilization screening levels. The maximum surface soil concentration of no volatile organic compound exceeded its corresponding soil-to-air volatilization screening level. As a result, the soil-to-air migration pathway is not expected to be significant at AOC 517.

10.6.4.6 Human Health Risk Assessment

10.6.4.6.1 Site Background and Investigative Approach

The purpose of the investigation at AOC 517 was the assessment of soil and interior building surfaces potentially affected by past site activities. AOC 517 is the former Indoor Firing Range, Building M-192, which operated from 1959 until 1974. Wastes generated at this site are spent lead slugs from the pistol range. Currently, the site serves as a classroom and storage area. Five upper interval soil samples were collected at AOC 571. Table 10.6.4.6 provides a list of analytical methods used to analyze soil samples. Seven wipe samples were also collected from interior surfaces in and around Building M-192. These samples were analyzed for lead. The analyses were semi-quantitative in that the wipe area was not precisely measured for each sample. The intent of the sampling effort was to confirm or refute the presence of lead on interior surfaces. As a result, data are discussed in the following sections, but no formal quantitative risk assessment was attempted.

AOC 517 is located within an area of NAVBASE slated to become community support and residential housing according to current base reuse plans. Building M-192 is not ideally suited to conversion to residential use, but could hypothetically be used as a daycare facility or educational building. If such use is proposed, additional sampling and formal risk characterization will be warranted. This assessment would necessarily utilize USEPA's Lead Uptake/Biokinetics Model

Table 10.6.4.5
Soil-to-Air Volatilization Screening Analysis
NAVBASE - Charleston Zone C, AOC 517
Charleston, South Carolina

VOCs	Maximum Concentratio in Surface Soil	Soil to Air SSL *	Units	Exceeds SSL
Acetone	0.028	100000	MG/KG	NO

* - Soil-to-air RBCs were obtained from USEPA Soil Screening Guidance: Technical Background Document, May 1996.

Table 10.6.4.6
Methods Run at AOC 517
Surface Soil

Site	Location	Metal	SVOA	VOA	Cn	Hexa	Diox	Oppe	Herb	Pest	Tph	Otin	Eng
517	B001	Y	Y	Y	Y					Y			
517	B002	Y	Y	Y	Y					Y			
517	B003	Y	Y	Y	Y					Y			
517	B004	Y	Y	Y	Y					Y			
517	B005	Y	Y	Y	Y					Y			

METHODS:

- Metal: TAL (Target Analyte List) Metals plus tin: Methods: 6000/7000 Series
- VOA: Volatile Organic Analysis: Method 8240
- SVOA: Semi-volatile Organic Analysis: Method 8270
- Cn: Cyanide (Soil: Method 9010, Water: Method 9012)
- Hexa: Hexavalent Chromium: Method 7195
- Diox: Dioxins
- Oppe: Organophosphate Pesticides: Method 8140
- Herb: Chlorinated Herbicides: Method 8150
- Pest: Chlorinated Pesticides: Method 8080
- Tph: Total Petroleum Hydrocarbons
- Otin: Organotin
- Eng: Engineering Parameters

KEY:

- Y: Analyzed for standard list
- D: Duplicate Analysis
- IR: Method 4181
- DR: Extraction Method 3550, GC Method 8100
- GR: Extraction Method 5030, GC Method 8015

Blank value indicates this method of analysis was not performed

(Version 0.99d) (Lead Model) to predict mean blood lead levels in children based on exposure to impacted environmental media.

10.6.4.6.2 COPC Identification

Soil

Based on the screening comparisons described in Section 7 of this RFI, and presented in Table 10.6.4.7, no upper interval soil COCs were identified. In addition, no COPCs were identified based on the results of Wilcoxon rank sum test analyses.

Building Surfaces

Lead was detected in each wipe sample at concentrations ranging from 55 to 21,500 μg/wipe. All wipe samples were collected from surfaces in and around the area formerly used as an indoor firing range. The maximum lead wipe concentration was reported in a sample collected from the rafters in the southeast equipment storage closet. Floor level concentrations have likely been reduced over time through normal housekeeping practices (i.e. floor wet mopping, etc.).

10.6.4.7 Corrective Measures Considerations

No further action is required based on the analytical results and risk assessment. No COCs were identified. Collected wipe samples confirmed the presence of lead inside the building. However, the matter is outside the scope of the RCRA corrective action requirements.

Table 10.6.4.7
Summary of Chemicals Present in Site Samples, AOC 517
Surface Soil
NAVBASE - Charleston, Zone C
Charleston, South Carolina

NAME	CONC UNITS	FREQ	DETECTS Min	DETECTS Max	DETECTS Avg	SCREENING Value	SCREENING # Over	SCREENING Source	NON-DETECTS Min	NON-DETECTS Max	BACKGROUND Value	BACKGROUND # Over
PCBs												
Aroclor-1260	UG/KG	1 - 5	79	79	79.00	83		C	21	21		
Inorganics												
Aluminum (Al)	MG/KG	5 - 5	3450	6620	5530.00	7800		N			9990	
Antimony (Sb)	MG/KG	3 - 5	0.41	0.55	0.47	3.1		N	0.2	0.2	0.55	1
Arsenic (As)	MG/KG	5 - 5	0.59	1.9	1.26	0.43	5	C			14.2	
Barium (Ba)	MG/KG	5 - 5	10.6	18.6	15.30	550		N			77.2	
Calcium (Ca)	MG/KG	5 - 5	185	9770	3973.80	NA						
Chromium (Cr)	MG/KG	5 - 5	5.3	10.1	6.54	39		N			26.4	
Cobalt (Co)	MG/KG	5 - 5	0.54	1.6	0.79	470		N			3.22	
Copper (Cu)	MG/KG	5 - 5	1.6	19.4	6.64	310		N			34.7	
Iron (Fe)	MG/KG	5 - 5	1760	3040	2416.00	NA		N				
Lead (Pb)	MG/KG	5 - 5	7.3	194	77.38	400		j			330	
Magnesium (Mg)	MG/KG	5 - 5	247	320	272.60	NA						
Manganese (Mn)	MG/KG	5 - 5	15.3	27.3	20.40	180		N			92.5	
Mercury (Hg)	MG/KG	1 - 5	0.16	0.16	0.16	2.3		N	0.1	0.11	0.24	
Nickel (Ni)	MG/KG	5 - 5	2.3	4.8	3.02	160		N			12.3	
Potassium (K)	MG/KG	5 - 5	104	172	138.80	NA						
Selenium (Se)	MG/KG	1 - 5	0.58	0.58	0.58	39		N	0.45	0.47	1.44	
Tin (Sn)	MG/KG	5 - 5	0.79	3.3	1.88	4700					2.95	1
Vanadium (V)	MG/KG	5 - 5	4.4	6.9	5.16	55		N			23.4	
Zinc (Zn)	MG/KG	5 - 5	9.5	106	46.82	2300		N			159	
Chlorinated Pesticides												
4,4'-DDE	UG/KG	3 - 5	5.2	9.8	7.53	1900		C	3.7	3.7		
Endosulfan I	UG/KG	1 - 5	2.2	2.2	2.20	47000		N	1.6	1.6		
Endosulfan sulfate	UG/KG	3 - 5	2.6	3.2	2.93	47000		g	2.1	2.1		
Endrin aldehyde	UG/KG	2 - 5	1.2	1.6	1.40	2300		h	1	1.1		
Semivolatile Organics												
bis(2-Ethylhexyl)phthalate (BEHP)	UG/KG	2 - 5	74	540	307.00	46000		C	790	800		

Table 10.6.4.7
Summary of Chemicals Present in Site Samples, AOC 517
Surface Soil
NAVBASE - Charleston, Zone C
Charleston, South Carolina

NAME	CONC UNITS	FREQ	DETECTS Min	DETECTS Max	DETECTS Avg	SCREENING Value	SCREENING # Over	SCREENING Source	NON-DETECTS Min	NON-DETECTS Max	BACKGROUND Value	BACKGROUND # Over
Butylbenzylphthalate	UG/KG	1 - 5	720	720	720.00	1600000		N	710	720		
Di-n-butylphthalate	UG/KG	5 - 5	49	89	65.80	780000		N				
Volatile Organics												
Acetone	UG/KG	1 - 5	28	28	28.00	780000		N	93	96		

Notes:
- * Retained as a chemical of potential concern
- C The RBC is based on carcinogenic effects
- N The RBC is based on noncarcinogenic effects
- j Screening level is set equal to the soil action level
- h The RBC for endrin is used as a surrogate
- g The RBC for endosulfan is used as a surrogate

10.6.5 AOC 518 — Coal Storage Bins

Coal was stored in bins at AOC 518 from 1926 until 1937. This site is currently a gravel and asphalt parking area and is partially covered by Building M-1257. A CSI was performed at AOC 518 to identify impacts to soil resulting from coal storage onsite. Potential contaminants include coal derivatives (SVOCs) and metals.

10.6.5.1 Soil Sampling and Analysis

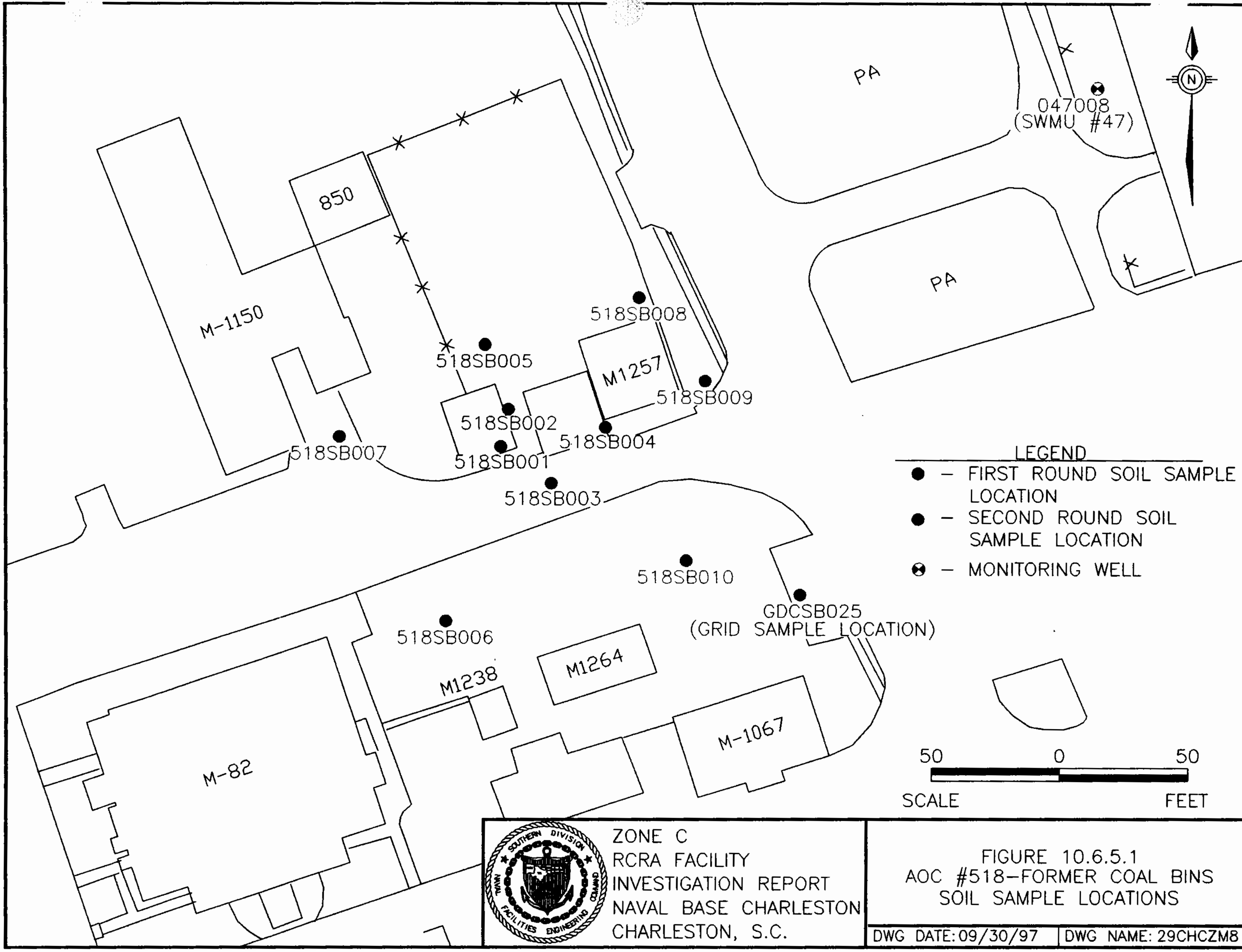
Soil sampling was conducted in accordance with the *Final Zone C Work Plan* (E/A&H, November 1995) and as outlined in Section 3 of this report. Sampling locations were selected following review of historical maps of the area and were placed at locations most likely impacted if a release had occurred. Figure 10.6.5.1 shows soil sample locations.

Soil samples were collected in two rounds. Ten soil samples were collected from five locations during the first round (one upper interval and one lower interval sample per location). One soil boring was not completed because the concrete in Building M-1257 could not be penetrated. First round samples were analyzed for VOCs, SVOCs, pesticides/PCBs, metals, and cyanide at DQO Level III. One duplicate sample was collected and submitted for Appendix IX analyses at DQO Level IV. This includes the parameters listed above as well as herbicides, hexavalent chromium, organophosphorous pesticides, and dioxins. Table 10.6.5.1 summarized the first round soil sampling and analysis.

Table 10.6.5.1
First Round — Soil Sampling and Analysis Summary
AOC 518 — Coal Storage Bins

Interval	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
Upper	6	5	Standard Suite[a]	Standard Suite[a]	One boring was not completed, concrete could not be penetrated.
Lower	6	5	Standard Suite[a]	Standard Suite[a]	

Note:
[a] = Standard suite includes VOCs, SVOCs, metals, cyanide, and pesticide/PCBs.



ZONE C
RCRA FACILITY
INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 10.6.5.1
AOC #518–FORMER COAL BINS
SOIL SAMPLE LOCATIONS

DWG DATE: 09/30/97 | DWG NAME: 29CHCZM8

First round soil data were compared to the USEPA Region III *Risk-Based Concentration Table*; June 1996. This preliminary review indicated that BaP exceeded its RBC of 88 μg/kg at locations 518SB001 and 518SB002 in the upper interval, and chlordane exceeded its RBC of 490 μg/kg at 518SB001 in the upper interval and lower intervals. Also, copper was indicated at a concentration above the March-1995 RBC of 290 mg/kg at location 518SB004. During the second-round sampling, five supplemental sample locations were added near these locations to delineate the extent of SVOC and pesticide contamination. Boring locations were selected to provide a boundary of the chlordane detection and not to assess treatment of buildings for termites and other pests. Upper interval soil samples were collected from each location. Two sample locations were analyzed for pesticides (518SB006 and 518SB007), one for SVOCs (518SB007), and three were analyzed for metals, (518SB008, 518SB009, 518SB010). One duplicate sample was collected and submitted for Appendix IX analyses at DQO Level IV. This includes the parameters listed above as well as herbicides, hexavalent chromium, organophosphorous pesticides, and dioxins. Table 10.6.5.2 summarizes the second round sampling and analysis.

Table 10.6.5.2
AOC 518 — Coal Storage Bins
Second Round — Soil Sampling and Analysis Summary

Interval	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
Upper	0	5	(1) SVOCs, (2) pesticides, (3) metals	(1) SVOCs, (2) pesticides, (3) metals	Added
Lower	0	0	None	None	None

10.6.5.2 Nature and Extent of Soil Contamination

Soil analytical results for organics are in Table 10.6.5.3, and results for inorganics are in Table 10.6.5.4. Appendix D is a complete analytical report for Zone C, including AOC 518. Appendix H contains detection only summary tables.

Volatile Organic Compounds in Soil 1

Three VOCs were detected in soil samples: methylene chloride, toluene, and acetone. All VOCs 2
were below their respective RBCs. 3

Table 10.6.5.3
Organic Compound Analytical Results for Soil
AOC 518 — Coal Storage Bins

Compound	Sample Interval	Frequency of Detection[a]	Range of Detection	Mean	RBC[a]	Number of Samples Exceeding RBC
Volatile Organic Compounds (µg/kg) **(Upper Interval — 5 Samples plus 2 Duplicates/Lower Interval — 5 Samples)**						
Methylene chloride	Upper	1/6	12.0	NA	85,000	0
Toluene	Upper	4/6	1.0 - 3.0	2.0	1,600,000	0
Acetone	Upper	2/6	24.0 - 34.0	29.0	780,000	0
	Lower	4/5	10.0 - 48.0	27.75	800	0
Semivolatile Organic Compounds (µg/kg) **(Upper Interval — 6 Samples plus 2 Duplicates/Lower Interval — 5 Samples)**						
Anthracene	Upper	1/7	39.0	NA	2,300,000	0
Benzo(a)anthracene	Upper	2/7	80.0 - 140.0	110.0	880[b]	0
Benzo(a)pyrene	Upper	2/7	69.0 - 150.0	109.5	88[b]	1
Benzo(b)fluoranthene	Upper	2/7	200.0 - 270.0	235.0	880[b]	0
Benzo(k)fluoranthene	Upper	2/7	210.0 - 290.0	250.0	8,800[b]	0
Chrysene	Upper	2/7	150.0 - 180.0	165.0	8,800[b]	0
Diethylphthalate	Upper	1/7	140.0	NA	6,300,000	0
Di-n-Butylphthalate	Upper	2/7	40.0 - 860.0	450.0	78,000	0
	Lower	1/5	40.0	NA	12,000	0
Di-n-Octylphthalate	Upper	1/7	70.0	NA	160,000	0
Di-n-Phenylamine	Upper	1/7	130.0	NA	200,000	0
Fluoranthene	Upper	3/7	41.0 - 270.0	183.7	310,000	0
Fluorene	Upper	1/7	40.0	NA	310,000	0
N-Nitroso-di-n-phenylamine	Upper	1/7	130.0	NA	130,000	0
Phenanthrene	Upper	2/7	84.0 - 240.0	162.0	230,000	0

Table 10.6.5.3
Organic Compound Analytical Results for Soil
AOC 518 — Coal Storage Bins

Compound	Sample Interval	Frequency of Detection[a]	Range of Detection	Mean	RBC[a]	Number of Samples Exceeding RBC
Pyrene	Upper	3/7	43.0 - 430.0	237.7	230,000	0
Bis(2-Ethylhexyl)phthalate	Upper	2/7	490.0 - 910.0	700.0	46,000	0
Butylbenzylphthalate	Upper	1/7	100.0	NA	1,600,000	0
BEQs	Upper	2/7	99.3 - 194.1	146.7	88	2
Pesticide and PCB Compounds (μg/kg) (Upper Interval — 7 Samples plus 2 Duplicates/Lower Interval — 5 Samples)						
beta-BHC	Upper	3/7	1.5 - 3.9	2.6	350	0
delta-BHC	Upper	2/7	.77 - 7.4	4.85	350	0
gamma-BHC	Upper	1/7	3.9	NA	490	0
Chlordane	Upper	3/7	48.0 - 7,400.0	2,503.5	490	1
	Lower	1/5	1,800	NA	2,000	0
4,4-DDD	Upper	3/7	3.8 - 58.0	25.3	2,700	0
4,4-DDE	Upper	4/7	3.9 - 180.0	60.2	1,900	0
4,4-DDT	Upper	4/7	8.6 - 130.0	69.3	1,900	0
Dieldrin	Upper	1/7	3.5	NA	40	0
Endosulfan II	Upper	1/7	3.4	NA	47,000	0
Endosulfan sulfate	Upper	3/7	1.9 - 6.7	3.83	47,000	0
Endrin	Upper	1/7	10.1	NA	2,300	0
Endrin aldehyde	Upper	3/7	1.5 - 2.1	1.7	2,300	0
Heptachlor	Upper	3/7	1.60 - 69.0	25.79	140	0
Hetachlor epoxide	Upper	1/7	0.97	NA	70	0
Methoxychlor	Upper	1/7	32.0	NA	39,000	0
Herbicide Compounds (μg/kg) (Upper Interval — 1 Duplicate Sample)						
2,4,5-Trichlorophenoxyacetic acid	Upper	1/2	3.10	NA	78,000	0
Dinoseb	Upper	1/2	20.0	NA	7,800	0

Table 10.6.5.3
Organic Compound Analytical Results for Soil
AOC 518 — Coal Storage Bins

Compound	Sample Interval	Frequency of Detection[a]	Range of Detection	Mean	RBC[a]	Number of Samples Exceeding RBC
Dioxins in Soil (ng/kg) (Upper Interval — 2 Duplicate Samples)						
1234678-HpCDD	Upper	2/2	30.49 - 89.63	60.06	NA	NA
1234678-HpCDF	Upper	2/2	20.84 - 2,179.65	1,100.23	NA	NA
123478-HxCDF	Upper	2/2	2.83 - 110.84	56.84	NA	NA
1234789-HpCDF	Upper	2/2	0.65 - 49.73	25.19	NA	NA
123678-HxCDD	Upper	2/2	1.49 - 18.52	10.01	NA	NA
123678-HxCDF	Upper	2/2	0.66 - 76.52	38.59	NA	NA
12378-PeCDD	Upper	1/2	21.37	NA	NA	NA
12378-PeCDF	Upper	1/2	13.50	NA	NA	NA
123789-HxCDF	Upper	1/2	3.853	NA	NA	NA
234678-HxCDF	Upper	2/2	1.35 - 10.45	NA	NA	NA
23478-PeCDF	Upper	1/2	2.01	NA	NA	NA
2378-TCDD	Upper	1/2	6.55	NA	NA	NA
OCDD	Upper	2/2	186.41 - 602.90	394.66	NA	NA
OCDF	Upper	2/2	30.87 - 9,424.61	4,727.74	NA	NA
TEQ	Upper	2/2	1.37 - 74.1	37.8	1,000	0
Organophosphorous Pesticide Compounds (μg/kg) (Upper Interval — 2 Duplicates)						
Disulfoton	Upper	1/2	5.3	NA	310	0

Notes:
[a] = Noncarcinogenic RBCs were adjusted to equate to a hazard quotient of 0.1.
[b] = These compounds are cPAHs and were multiplied by the appropriate BEF for comparison as BEQs.
All results are in micrograms per kilogram (μg/kg) except dioxins which are in nanograms per kilogram (ng/kg).

Table 10.6.5.4
Inorganic Analytical Results for Soil
AOC 518 — Coal Storage Bins
(Upper Interval — 8 Samples plus 2 Duplicates / Lower Interval — 5 Samples)

Analytes	Sample Interval	Frequency of Detection[a]	Range of Detection (mg/kg)	Mean (mg/kg)	Reference Conc. (mg/kg)	Number of Samples Exceeding Reference
Aluminum	Upper	9/9	4,640 - 10,000	6,004.50	9,990	1
	Lower	5/5	3,060 - 6,020	4,186.00	23,700	0
Antimony	Upper	7/9	0.23 - 1.70	0.77	0.55	3
Arsenic	Upper	5/9	1.2 - 3.9	2.65	14.2	0
	Lower	3/5	0.35 - 0.63	0.45	14.1	0
Barium	Upper	9/9	21.0 - 114.0	56.53	77.2	3
	Lower	5/5	9.8 - 19.9	13.30	68.5	0
Beryllium	Upper	1/9	0.490	NA	ND	1
Cadmium	Upper	3/9	0.73 - 1.20	0.89	0.65	3
Calcium	Upper	9/9	473 - 20,600	4,183.17	NA	0
	Lower	5/5	126.0 - 191.0	162.00	NA	0
Chromium	Upper	9/9	5.2 - 39.1	12.73	26.4	1
	Lower	5/5	4.8 - 6.3	5.72	12.5	0
Cobalt	Upper	9/9	0.43 - 1.60	1.10	3.22	0
	Lower	5/5	0.44 - 0.72	0.61	7.1	0
Copper	Upper	9/9	2.2 - 653.85	86.83	34.7	2
	Lower	4/5	1.0 - 4.0	2.18	42.2	0
Iron	Upper	9/9	2,390 - 4,250	3,347.78	NA	0
	Lower	5/5	1,580 - 3,030	2,156.00	NA	0
Lead	Upper	9/9	5.6 - 750.0	142.48	330	1
	Lower	5/5	2.6 - 6.5	4.00	73.2	0
Magnesium	Upper	9/9	261.5 - 577.0	381.06	NA	0
	Lower	5/5	180.0 - 317.0	242.80	NA	0
Manganese	Upper	9/9	22.8 - 58.4	41.30	92.5	0
	Lower	5/5	9.6 - 19.3	12.72	106	0

Table 10.6.5.4
Inorganic Analytical Results for Soil
AOC 518 — Coal Storage Bins
(Upper Interval — 8 Samples plus 2 Duplicates / Lower Interval — 5 Samples)

Analytes	Sample Interval	Frequency of Detection[a]	Range of Detection (mg/kg)	Mean (mg/kg)	Reference Conc. (mg/kg)	Number of Samples Exceeding Reference
Mercury	Upper	2/9	0.130 - 0.540	0.34	0.24	1
Nickel	Upper	9/9	2.0 - 5.0	3.48	12.3	0
	Lower	5/5	1.0 - 2.4	1.62	16.7	0
Potassium	Upper	9/9	127.5 - 754.0	264.61	NA	0
	Lower	5/5	123.0 - 158.0	141.60	NA	0
Selenium	Upper	6/9	0.49 - 1.00	0.74	1.44	0
	Lower	1/5	0.49	NA	2.90	0
Sodium	Upper	3/9	230.0 - 490.0	324.67	NA	0
Tin	Upper	9/9	0.8 - 12.75	3.12	2.95	2
	Lower	5/5	0.67 - 1.50	1.01	2.37	0
Vanadium	Upper	9/9	4.6 - 10.8	7.60	23.4	0
	Lower	5/5	3.0 - 5.0	3.94	56.9	0
Zinc	Upper	9/9	11.8 - 279.0	108.48	159	2
	Lower	5/5	3.3 - 16.5	7.24	243	0

Volatile Organic Compounds in Soil

Three VOCs were detected in the upper interval soil samples and one VOC was detected in the lower interval. Methylene chloride, toluene, and acetone were all detected below their RBCs in the upper interval. Aceton was below its SSL in the lower interval soil samples.

Semivolatile Organic Compounds in Soil

Eighteen SVOCs were detected in upper interval soil samples. Benzo(a)pyrene was detected at a concentration above its RBC of 88 μg/kg at one location, 518SB00101. One SVOC was detected in one lower interval sample below its SSL. The BEQs calculated for AOC 518 soil show exceedances of the BaP RBC at two upper interval sample locations (518SB002 and 512SB003).

Pesticides and PCBs in Soil

Fourteen pesticide compounds were detected in upper interval soil samples and one was detected in the lower interval samples. Chlordane was detected at 518SB001 at a concentration of 7,400 μg/Kg which is above it's RBC of 410 μg/Kg. As a result, five additional surface soil locations were sampled, none of which detected chlordane. Chlordane also was detected in the lower interval soil sample was below its SSL. No PCBs were detected in soil samples collected at AOC 518.

Other Organic Compounds in Soil

Other organic compounds include the Appendix IX compound groups that are not part of the standard analytical suite, including: herbicides, organophosphorous pesticides, and dioxins.

Herbicides — 2,4,5-trichlorophenoxyacetic acid and dinoseb — were detected below their RBCs. One organophosphorous pesticide, disulfoton was detected, but below its RBC.

Fourteen dioxins were detected in soil. The upper interval duplicate samples were submitted for Appendix IX analyses. RBCs do not exist for these parameters. The TEQs were calculated at 1.37 ng/kg and 74.1 ng/kg, below the TCDD RBC of 1,000 ng/kg.

Inorganic Elements in Soil

Twenty-two inorganic analytes were detected in upper interval soil samples, and 17 were detected in lower interval samples. Table 10.6.5.4 summarizes the inorganic analytical results from AOC 518. Eleven inorganics detected in the upper interval exceeded their respective reference concentration: aluminum, antimony, barium, beryllium, cadmium, chromium, copper, lead, mercury, tin, and zinc. All analytes detected in the lower interval were below their respective reference concentrations.

Cyanide was not detected in soil samples collected at AOC 518. Hexavalent chromium was not detected in the duplicate soil samples collected at AOC 518.

10.6.5.3 Fate and Transport Assessment

AOC 518, a former coal storage bin, is currently an asphalt and gravel parking area adjacent to Building M-1257. Migration pathways investigated for AOC 518 include soil to groundwater and emissions of volatile organic compounds from surface soil to air. Environmental media sampled as part of the AOC 518 RFI include surface soil and subsurface soil.

10.6.5.3.1 Soil-to-Groundwater Cross-Media Transport

Table 10.6.5.5 compares constituents found in both soil and groundwater to groundwater protection SSLs and background reference concentrations. Nine constituents (antimony, beta-BHC, delta-BHC, chromium, copper, disulfoton, lead, mercury, and tin) were detected in AOC 518 soil above groundwater protection SSLs or grid-based background reference concentrations. Diphenylamine could not be quantitatively evaluated regarding soil-to-groundwater migration in the absence of a groundwater protection SSL. All of these constituents were detected in surface soil above groundwater protection SSLs or background reference concentrations. However, these constituents were either not detected in subsurface soil or were detected at concentrations below their SSLs or reference concentrations.

Beta-BHC, delta-BHC, and disulfoton were detected in less than half of the samples analyzed and maximum concentrations were generally less than twice the SSL. Antimony, chromium, and mercury were each detected in surface soil above reference concentrations in only two or three samples with mean levels comparable to or less than background. Copper, lead, and tin each had

Table 10.6.5.5
Chemicals Detected in Surface Soil and Subsurface Soil
Comparison to Groundwater Protection SSLs and Background UTLs
\VBASE-Charleston, Zone C, AOC 518
arleston, South Carolina

Parameter	Surface Soil Maximum Conc.	Subsurface Soil Maximum Conc.	Ground Water Protection SSL or UTL *	Soil Units	Soil Conc. Exceeds SSL or UTL
Acetone	34	48	1600	UG/KG	NO
Aluminum	10000	6020	23700	MG/KG	NO
Anthracene	39	ND	1200000	UG/KG	NO
Antimony	1.7	ND	0.55	MG/KG	YES
Arsenic	3.9	0.63	29	MG/KG	NO
Barium	114	19.9	1600	MG/KG	NO
Benzo(a)pyrene Equivalents					
Benzo(a)pyrene	150	ND	8000	UG/KG	NO
Benzo(a)anthracene	140	ND	2000	UG/KG	NO
Benzo(b)fluoranthene	270	ND	5000	UG/KG	NO
Benzo(k)fluoranthene	290	ND	49000	UG/KG	NO
Chrysene	180	ND	160000	UG/KG	NO
Beryllium	0.49	ND	63	MG/KG	NO
beta-BHC	3.9	ND	3	UG/KG	YES
delta-BHC	7.4	ND	3	UG/KG	YES
gamma-BHC	3.9	ND	9	UG/KG	NO
Butylbenzylphthalate	100	ND	930000	UG/KG	NO
dmium	1.2	ND	8	MG/KG	NO
.ordane	7400	0.65	40000	UG/KG	NO
Chromium	39.1	6.3	38	MG/KG	YES
Cobalt	1.6	0.72	7.1	MG/KG	NO
Copper	653.9	4	42.2	MG/KG	YES
4,4'-DDD	58	ND	16000	UG/KG	NO
4,4'-DDE	180	6.7	54000	UG/KG	NO
4,4'-DDT	130	ND	32000	UG/KG	NO
Di-n-butylphthlate	860	40	2300000	UG/KG	NO
Dieldrin	3.5	ND	4	UG/KG	NO
Diethylphthalate	140	ND	47000	UG/KG	NO
Dinoseb	20	ND	170	UG/KG	NO
Di-n-octylphthalate	70	ND	10000000	UG/KG	NO
Dioxin (TCDD TEQ)	1.73	ND	4000	PG/G	NO
Diphenylamine	130	ND	NDA	UG/KG	YES
Disulfoton	5.3	ND	5	UG/KG	YES
Endosulfan	8.4	ND	1800	UG/KG	NO
Endrin	10.5	ND	1000	UG/KG	NO
Endrin aldehyde	2.1	ND	1000	UG/KG	NO
bis(2-Ethylhexyl)phthlate	910	ND	3600000	UG/KG	NO
Fluoranthene	270	ND	430000	UG/KG	NO
Fluorene	40	ND	56000	UG/KG	NO
Heptachlor	69	ND	23000	UG/KG	NO
Lead	750	6.5	330	MG/KG	YES
Manganese	58.4	19.3	106	MG/KG	NO
Mercury	0.54	ND	0.3	MG/KG	YES
Methoxychlor	32	ND	160000	UG/KG	NO
'hylene chloride	12	ND	20	UG/KG	NO
,kel	5	2.4	130	MG/KG	NO

Table 10.6.5.5
Chemicals Detected in Surface Soil and Subsurface Soil
Comparison to Groundwater Protection SSLs and Background UTLs
\VBASE-Charleston, Zone C, AOC 518
.arleston, South Carolina

Parameter	Surface Soil Maximum Conc.	Subsurface Soil Maximum Conc.	Ground Water Protection SSL or UTL *	Soil Units	Soil Conc. Exceeds SSL or UTL
N-Nitrosodiphenylamine	130	ND	1000	UG/KG	NO
Phenanthrene	240	ND	100000000	UG/KG	NO
Pyrene	430	ND	420000	UG/KG	NO
Selenium	1	0.49	5	MG/KG	NO
2,4,5-TP (Silvex)	3.1	ND	5300	UG/KG	NO
Tin	12.75	1.5	2.95	MG/KG	YES
Toluene	3	ND	12000	UG/KG	NO
Vanadium	10.8	5	600	MG/KG	NO
Zinc	279	16.5	1200	MG/KG	NO

* - See Table 6-2
NA - Not available
ND - Not detected
SSL - Groundwater protection soil screening level
UTL - Grid-based background upper tolerance limit
MG/KG - Milligram per kilogram
UG/KG - Micrograms per kilogram

one surface soil detection that deviated substantially from its reference concentration. Copper and tin were found at the southwest corner of M1257. The maximum lead result was reported in boring 10; the most distant sample from the AOC. As previously stated, subsurface results did not suggest that significant vertical migration had occurred. These findings indicate that although there is some potential for constituents leaching from the surface soil, significant impact to the shallow aquifer is not expected.

10.6.5.3.2 Soil-to-Air Cross-Media Transport

Table 10.6.5.6 lists the volatile organic compounds detected in surface soil samples collected at AOC 518, along with corresponding soil-to-air volatilization screening levels. The maximum surface soil concentration of no volatile organic compound exceeded its corresponding soil-to-air volatilization screening level. As a result, the soil-to-air migration pathway would not be expected to be significant at the site.

10.6.5.4 Human Health Risk Assessment

10.6.5.4.1 Site Background and Investigative Approach

Coal was stored in bins at AOC 518 from 1926 until 1937. This site is currently a gravel and asphalt parking area and is partially covered by Building M-1257. The purpose of the CSI investigation was to identify any impacts to soil resulting from the storage of coal onsite.

Ten soil samples were collected from the upper interval. Table 10.6.5.7 lists the analytical methods employed for the corresponding samples. The number of soil samples may differ for various groups of compounds because specific groups were targeted at certain sample locations and/or sampling rounds. No groundwater sampling was performed in conjunction with AOC 518.

Table 10.6.5.6
Soil-to-Air Volatilization Screening Analysis
NAVBASE - Charleston Zone C, AOC 518
Charleston, South Carolina

VOCs	Maximum Concentratio in Surface Soil	Soil to Air SSL *	Units	Exceeds SSL
Acetone	0.048	100000	MG/KG	NO
Methylene chloride	0.012	13	MG/KG	NO
Toluene	0.003	650	MG/KG	NO

* - Soil-to-air RBCs were obtained from USEPA Soil Screening Guidance: Technical Background Document, May 1996.

Table 10.6.5.7
Methods Run at AOC 518
Surface Soil

Site	Location	Metal	SVOA	VOA	Cn	Hexa	Diox	Oppe	Herb	Pest	Tph	Otin	Eng
518	B001	Y	Y	Y	Y					Y			Y
518	B002	Y	Y	Y	Y					Y			
518	B003	Y	Y	Y	Y					Y			
518	B004	D	D	D	D	Y	Y	Y	Y	D			
518	B005	Y	Y	Y	Y					Y			
518	B006	Y	Y	Y	Y		Y	Y	Y	D			
518	B007		Y							Y			
518	B008	Y											
518	B009	Y											
518	B010	Y											

METHODS:

Metal: TAL (Target Analyte List) Metals plus tin: Methods: 6000/7000 Series
VOA: Volatile Organic Analysis: Method 8240
SVOA: Semi-volatile Organic Analysis: Method 8270
Cn: Cyanide (Soil: Method 9010, Water: Method 9012)
Hexa: Hexavalent Chromium: Method 7195
Diox: Dioxins
Oppe: Organophosphate Pesticides: Method 8140
Herb: Chlorinated Herbicides: Method 8150
Pest: Chlorinated Pesticides: Method 8080
Tph: Total Petroleum Hydrocarbons
Otin: Organotin
Eng: Engineering Parameters

KEY:

Y: Analyzed for standard list
D: Duplicate Analysis
IR: Method 4181
DR: Extraction Method 3550, GC Method 8100
GR: Extraction Method 5030, GC Method 8015
Blank value indicates this method of analysis was not performed

10.6.5.4.2 COPC Identification

Soil

Based on the screening comparisons described in Section 7 of this RFI and presented in Table 10.6.5.8, five surface soil COPCs were identified: BEQs, beryllium, chlordane, copper, and lead. Aluminum was identified as a COPC based on the results of Wilcoxon rank sum test analyses. Although the maximum chromium result exceeded its RBC and reference concentration, it was not included as a COPC. The RBC used for screening represents that for hexavalent chromium. Hexavalent chromium was not detected in AOC 518 soil, indicating that chromium exists predominantly in the trivalent valence state. The trivalent chromium residential RBC is 7,800 mg/kg, and the maximum onsite result was well below this value. As a result, chromium was not carried over to the formal assessment.

10.6.5.4.3 Exposure Assessment

Exposure Setting

AOC 518 is currently a gravel and asphalt parking area and includes Building M-1257. This AOC is in an area slated to be used as community support and/or residential property according to base reuse plans.

Potentially Exposed Populations

Potentially exposed populations are current and future site workers. Additional potentially exposed populations are hypothetical future site residents. Future site resident and worker exposure scenarios were addressed in this human health risk assessment. The hypothetical future site worker scenario assumes continuous exposure to surface soil conditions. Current site workers' exposure would be less than that assumed for the hypothetical future site worker scenario because of their limited soil contact (the area is currently mostly asphalt or covered by Building M-1257). Therefore, future worker assessment is considered to be protective of current site users.

Table 10.6.5.8
Summary of Chemicals Present in Site Samples, AOC 518
Surface Soil
NAVBASE - Charleston, Zone C
Charleston, South Carolina

NAME	CONC UNITS	FREQ	DETECTS Min	DETECTS Max	DETECTS Avg	SCREENING Value	SCREENING # Over	SCREENING Source	NON-DETECTS Min	NON-DETECTS Max	BACKGROUND Value	BACKGROUND # Over
Chromium (Cr)	MG/KG	9 - 9	5.2	39.1	12.73	39	1	N			26.4	1
Cobalt (Co)	MG/KG	9 - 9	0.43	1.6	1.10	470		N			3.22	
Copper (Cu)	MG/KG	9 - 9	2.2	653.85	86.83	310	1	N			34.7	2
Iron (Fe)	MG/KG	9 - 9	2390	4250	3347.78	NA		N				
Lead (Pb)	MG/KG	8 - 9	5.6	750	151.40	400	1	j	71.1	71.1	330	1
Magnesium (Mg)	MG/KG	9 - 9	261.5	577	381.06	NA						
Manganese (Mn)	MG/KG	9 - 9	22.8	58.4	41.30	180		N			92.5	
Mercury (Hg)	MG/KG	2 - 9	0.13	0.54	0.34	2.3		N	0.09	0.11	0.24	1
Nickel (Ni)	MG/KG	9 - 9	2	5	3.48	160		N			12.3	
Potassium (K)	MG/KG	9 - 9	127.5	754	264.61	NA						
Selenium (Se)	MG/KG	6 - 9	0.49	1	0.74	39		N	0.47	0.48	1.44	
Sodium (Na)	MG/KG	3 - 9	230	490	324.67	NA			96.9	206		
Tin (Sn)	MG/KG	9 - 9	0.8	12.75	3.12	4700					2.95	2
Vanadium (V)	MG/KG	9 - 9	4.6	10.8	7.60	55		N			23.4	
Zinc (Zn)	MG/KG	9 - 9	11.8	279	108.48	2300		N			159	2
Pesticides												
beta-BHC	UG/KG	3 - 7	1.5	3.9	2.63	350		C	1	12		
delta-BHC	UG/KG	2 - 7	0.77	7.4	4.09	100		I	1	12		
gamma-BHC (Lindane)	UG/KG	1 - 7	3.9	3.9	3.90	490		C	0.55	12		
Chlordane	UG/KG	3 - 7	48	7400	2503.50	490	1	C	4.2	11		
4,4'-DDD	UG/KG	3 - 7	3.8	58	25.27	2700		C	1.9	9.6		
4,4'-DDE	UG/KG	4 - 7	3.9	180	60.15	1900		C	3.6	41		
4,4'-DDT	UG/KG	4 - 7	9.8	130	50.95	1900		C	3.7	41		
Dieldrin	UG/KG	1 - 7	3.5	3.5	3.50	40		C	1.5	16		
Dinoseb	UG/KG	1 - 2	20	20	20.00	7800		N	26	26		
Disulfoton	UG/KG	1 - 2	5.3	5.3	5.30	310		N	11	11		
Endosulfan II	UG/KG	1 - 7	3.4	3.4	3.40	47000		N	3.6	41		
Endosulfan sulfate	UG/KG	3 - 7	1.9	6.7	3.83	47000		g	2	24		
Endrin	UG/KG	1 - 7	10.05	10.05	10.05	2300		N	2.6	27		
Endrin aldehyde	UG/KG	3 - 7	1.5	2.1	1.73	2300		h	1.1	12		
Heptachlor	UG/KG	3 - 7	1.595	69	26.20	140		C	1	2.7		
Heptachlor epoxide	UG/KG	1 - 7	0.97	0.97	0.97	70		C	1	12		

Table 10.6.5.8
Summary of Chemicals Present in Site Samples, AOC 518
Surface Soil
NAVBASE - Charleston, Zone C
Charleston, South Carolina

NAME	CONC UNITS	FREQ	DETECTS Min	DETECTS Max	DETECTS Avg	SCREENING Value	SCREENING # Over	SCREENING Source	NON-DETECTS Min	NON-DETECTS Max	BACKGROUND Value	BACKGROUND # Over
Methoxychlor	UG/KG	1 - 7	32	32	32.00	39000		N	3.6	41		
2,4,5-TP (Silvex)	UG/KG	1 - 2	3.1	3.1	3.10	63000		N	130	130	I	
Semivolatile Organics												
Anthracene	UG/KG	1 - 7	39	39	39.00	2300000		N	770	880		
bis(2-Ethylhexyl)phthalate (BEHP)	UG/KG	2 - 7	490	910	700.00	46000		C	780	890		
Butylbenzylphthalate	UG/KG	1 - 7	100	100	100.00	1600000		N	710	810		
Di-n-butylphthalate	UG/KG	2 - 7	40	860	450.00	780000		N	820	920		
Diethylphthalate	UG/KG	1 - 7	140	140	140.00	6300000		N	750	860		
Di-n-octyl phthalate	UG/KG	1 - 7	70	70	70.00	160000		N	500	570		
Diphenylamine	UG/KG	1 - 7	130	130	130.00	200000		N	1500	1700		
Fluoranthene	UG/KG	3 - 7	41	270	183.67	310000		N	960	1100		
Fluorene	UG/KG	1 - 7	40	40	40.00	310000		N	720	820		
N-Nitrosodiphenylamine	UG/KG	1 - 7	130	130	130.00	130000		C	1500	1700		
Phenanthrene	UG/KG	2 - 7	84	240	162.00	310000		f	640	740		
Pyrene	UG/KG	3 - 7	43	430	237.67	230000		N	760	870		
Volatile Organics												
Acetone	UG/KG	2 - 6	24	34	29.00	780000		N	94	99		
Methylene chloride	UG/KG	1 - 6	12	12	12.00	85000		C	21	40		
Toluene	UG/KG	4 - 6	1	3	2.00	1600000		N	16	18		

Notes:
- * Retained as a chemical of potential concern
- C The RBC is based on carcinogenic effects
- N The RBC is based on noncarcinogenic effects
- j Screening level is set equal to the soil action level
- I The RBC for gamma-BHC is used as a surrogate
- g The RBC for endosulfan is used as a surrogate
- h The RBC for endrin is used as a surrogate
- f The RBC for fluoranthene is used as a surrogate

Exposure Pathways

Exposure pathways for the site workers are dermal contact and incidental ingestion of surface soil. The exposure pathways for future residential land use are the same as those for the future site worker. In addition, the hypothetical future site worker scenario assumes continuous exposure to surface soil conditions. Uniform exposure was assumed for all sample locations. Table 10.6.5.9 presents the justification for exposure pathways assessed in this human health risk assessment.

Table 10.6.5.9
Exposure Pathways Summary
NAVBASE — Zone C
Charleston, South Carolina

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Current Land Uses			
Current Site Users/Maintenance	Air, Inhalation of gaseous contaminants emanating from soil	No	No significant VOC concentrations were reported in surface soils, and portions of the site area are paved/covered by buildings.
	Air, Inhalation of chemicals entrained in fugitive dust	No	Portions of the site area are paved/covered by buildings, which limits fugitive dust generation.
	Shallow groundwater, Ingestion of contaminants during potable or general use	No	Shallow groundwater is not currently used as a source of potable or non-residential water at AOC 518.
	Shallow groundwater, Inhalation of volatilized shallow groundwater contaminants	No	Shallow groundwater is not currently used as a source of potable or non-residential water at AOC 518.
	Soil, Incidental ingestion	No (Qualified)	Future land use assessment is considered to be protective of current receptors.
	Soil, Dermal contact	No (Qualified)	Future land use assessment is considered to be protective of current receptors
Future Land Uses			
Future Site Residents (Child and Adult) and Future Site Worker	Air, Inhalation of gaseous contaminants emanating from soil	No	No significant VOC concentrations were reported in surface soils, and portions of the site area are paved/covered by buildings.
	Air, Inhalation of chemicals entrained in fugitive dust	No	Portions of the site area are paved/covered by buildings, which limits fugitive dust generation.
	Shallow groundwater, Ingestion of contaminants during potable or general use	No	No groundwater sampling was performed in conjunction with the 518 investigation.

Table 10.6.5.9
Exposure Pathways Summary
NAVBASE — Zone C
Charleston, South Carolina

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
	Shallow groundwater, Inhalation of volatilized contaminants during domestic use	No	No groundwater sampling was performed in conjunction with the 518 investigation.
	Soil, Incidental ingestion	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Soil, Dermal contact	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Wild game or domestic animals, Ingestion of tissue impacted by media contamination	No	Hunting/taking of game and/or raising livestock is prohibited within the Charleston, South Carolina, City Limits.
	Fruits and vegetables, Ingestion of plant tissues grown in media	No	The potential for significant exposure via this pathway is low relative to that of other exposure pathways assessed.

Exposure Point Concentrations

Upper confidence limits are calculated for datasets consisting of at least 10 samples. Fewer than 10 surface soil samples were analyzed for each of the COPCs identified. As a result, the maximum concentration of each was applied as the EPC. Due to the small area of investigation and limited extent of some COPCs, a hot-spot approach was used to modify the EPCs for BEQs, chlordane, and beryllium. No FI/FC factor was derived for aluminum, lead or copper. The hot-spot evaluation considered the areal extent of specific chemical impacts relative to a standard one-half acre exposure range.

BEQs were detected in two of six samples analyzed (518SB002 and 518SB003), which were isolated to an area between and immediately adjacent to the footprints of former coal bins (estimated area approximately 2,000 square feet). Based on this conservative projection of the impacted fraction of a standard one-half acre evaluation area, an FI/FC factor of 0.1 was estimated.

Chlordane was detected at locations 518SB001, 518SB004 and 518SB006 of the seven sampled. Sample 518SB00101 was the only one with a chlordane concentration in excess of the residential RBC. This detection was immediately adjacent to or beneath the projected footprint of the former coal bins. Considering the footprint of former building M-1123 (700 square feet estimated) to represent the extent of significant chlordane concentrations, an FI/FC factor of 0.1 was conservatively estimated.

Beryllium was detected in one of nine samples collected (518SB005). This sample was collected north of the former coal bins and represented the most distant of the samples from the suspect source area. Based on its extremely limited extent, an FI/FC factor of 0.1 was estimated. This factor was also supported by estimation of the area represented by this single detection (less than 1,500 square feet).

Quantification of Exposure

Soil

Chronic daily intakes for ingestion and dermal contact with soils are shown in Tables 10.6.5.10 and 10.6.5.11 respectively.

10.6.5.4.4 Toxicity Assessment

Toxicity assessment terms and methods are discussed in Section 7 of this report. Table 10.6.5.12 presents toxicological information specific to COPCs identified at AOC 518. This information was used in the quantification of risk/hazard associated with soil contaminants. Brief toxicological profiles are provided in the following paragraphs.

Table 10.6.5.10
Chronic Daily Intakes (CDI)
Incidental Ingestion of Surface Soil (0-1')
AOC 518 Zone C
Naval Base Charleston
Charleston, SC

Chemical	TEF	Fraction Ingested fro Contaminate Source	Exposure Point Concentration (mg/kg)	Potential Future Resident adult H-CDI (mg/kg-day)	Potential Future Resident child H-CDI (mg/kg-day)	Potential Futur Resident lwa C-CDI (mg/kg-day)	Potential Curren Worker adult H-CDI (mg/kg-day)	Potential Current Worker adult C-CDI (mg/kg-day)
Benzo(a)pyrene Equival	1	0.1	0.194	2.66E-08	2.48E-07	3.04E-08	9.49E-09	3.39E-09
Chlordane	NA	0.1	7.4	1.01E-06	9.46E-06	1.16E-06	3.62E-07	1.29E-07
Aluminum	NA	1	10000	1.37E-02	1.28E-01	1.57E-02	4.89E-03	1.75E-03
Beryllium	NA	0.1	0.49	6.71E-08	6.26E-07	7.67E-08	2.40E-08	8.56E-09
Lead	NA	1	750	1.03E-03	9.59E-03	1.17E-03	3.67E-04	1.31E-04
Copper	NA	1	653.0	8.95E-04	8.35E-03	1.02E-03	3.19E-04	1.14E-04

NOTES:

TEF toxic equivalency factor relative to Benzo(a)pyrene
lwa lifetime weighted average; used to calculate carcinogenic CDI, RAGS Parts A and B
CDI Chronic Daily Intake in mg/kg-day
H-CDI CDI for hazard quotient
C-CDI CDI for excess cancer risk
* Reflects the estimated fraction of the site impacted by the corresponding COPC.

Table 10.6.5.11
Chronic Daily Intakes (CDI)
Dermal Contact with Surface Soil (0-1')
AOC 518 Zone C
Naval Base Charleston
Charleston, SC

Chemical	TEF	Adjusted Exposure Point Concentration (mg/kg)	Fraction Contacted fro Contaminated Source *	Dermal Absorption Factor (unitless)	Potential Future Resident adult H-CDI (mg/kg-day)	Potential Future Resident child H-CDI (mg/kg-day)	Potential Futur Resident lwa C-CDI (mg/kg-day)	Potential Curren Worker adult H-CDI (mg/kg-day)	Potential Current Worker adult C-CDI (mg/kg-day)
Benzo(a)pyrene Equival	1	0.194	0.1	0.01	1.09E-08	3.60E-08	6.82E-09	7.78E-09	2.78E-09
Chlordane	NA	7.4	0.1	0.01	4.16E-07	1.37E-06	2.60E-07	2.97E-07	1.06E-07
Aluminum	NA	10000	1	0.001	5.62E-04	1.85E-03	3.52E-04	4.01E-04	1.43E-04
Beryllium	NA	0.49	0.1	0.001	2.75E-09	9.08E-09	1.72E-09	1.97E-09	7.02E-10
Lead	NA	750	1	0.001	4.21E-05	1.39E-04	2.64E-05	3.01E-05	1.07E-05
Copper	NA	653	1	0.001	3.67E-05	1.21E-04	2.30E-05	2.62E-05	9.36E-06

NOTES:

TEF Toxic Equivalency Factor relative to Benzo(a)pyrene
CDI Chronic Daily Intake in mg/kg-day
H-CDI CDI for hazard quotient
C-CDI CDI for excess cancer risk
- The dermal absorption factor was applied to the exposure point concentration to reflect the different trans-dermal migration of inorganic versus organic chemicals
* Reflects the estimated fraction of the site impacted by the corresponding COPC.

Table 10.6.5.12
Toxicological Database Informatio
for Chemicals of Potential Concer
AOC 518
NAVBASE Charleston, Zone C

Non-Carcinogenic Toxicity Data

Chemical	Oral Reference Dose (mg/kg/day)		Confidence Level	Critical Effect	Uncertainty Factor Oral	Inhalation Reference Dose (mg/kg/day)	Confidence Level	Critical Effect	Uncertainty Factor Inhalation
Benzo(a)pyrene Equivalents	ND				ND	ND			ND
Beryllium	0.005	a	L	microscopic organ changes	100	ND			ND
Chlordane	6E-05	a	L	liver hypertrophy		ND			ND
Copper	0.0371	b	NA	NA	ND	ND			ND
Lead	ND				ND	ND			ND

NOTES:

a Integrated Risk Information System (IRIS)
b Health Effects Assessment Summary Tables (HEAST)
c HEAST alternative method
d USEPA Region III Screening Tables
e EPA Environmental Criteria and Assessment Office - Cincinnati (provisional)
f Withdrawn from IRIS or HEAST
Toxicological data for naphthalene were used as surrogates for 2-methylnaphthalene.
NA Not applicable or not available
ND Not determined due to lack of information

Table 10.6.5.12
Toxicological Database Informatio
for Chemicals of Potential Concer
AOC 518
NAVBASE Charleston, Zone C

Carcinogenic Toxicity Data

Chemical	Oral Slope Factor [(mg/kg/day)]-1		Inhalation Slope Factor [(mg/kg/day)]-1		Weight of Evidence	Tumor Type
Benzo(a)pyrene Equivalents	7.3	a			B2	mutagen
Beryllium	4.3	a	8.4	a	B2	osteosarcoma
Chlordane	1.3	a	ND		B2	liver carcinoma
Copper	ND		ND		D	
Lead	ND		ND		B2	various

Polyaromatic Hydrocarbons or BaP equivalents include the following list of COPCs:

Benzo(a)anthracene	TEF	0.1
Benzo(b)fluoranthene	TEF	0.1
Dibenz(a,h)anthracene	TEF	1.0
Benzo(k)fluoranthene	TEF	0.01
Benzo(a)pyrene	TEF	1.0
Indeno(1,2,3-cd)pyrene	TEF	0.1
Chrysene	TEF	0.001

Some PAHs are toxic to the liver, kidneys, and blood. However, the toxic effects of the PAHs above have not been well established. There are no RfDs for the PAHs above due to a lock of data. All PAHs listed above are classified by USEPA as B2 carcinogens, and their carcinogenicity is addressed relative to that of BaP, having an oral SF of 7.3 mg/kg-day^{1}. Toxicity Equivalency Factors, also set by USEPA, are multipliers that are applied to the detected concentrations, with the results subsequently used to calculate excess cancer risk. These multipliers are discussed further in the exposure and toxicity assessment sections. Most carcinogenic PAHs have been classified as such due to animal studies using large doses of purified PAHs. There is some doubt as to the validity of these listings, and the SFs listed in USEPA's RBC table are provisional. However, these PAHs are carcinogens when the exposure involves a mixture of other carcinogenic substances (e.g., coal tar, soot, cigarette smoke, etc.). As listed in IRIS (search data June 28, 1995), the basis for the BaP B2 classification is human data specifically linking BaP to a carcinogenic effect are lacking. There are, however, multiple animal studies in many species demonstrating BaP to be carcinogenic by numerous routes.

BaP has produced positive results in numerous genotoxicity assays. At the June 1992 CRAVE Work Group meeting, a revised risk estimate for BaP was verified (see Additional Comments for Oral Exposure). This section provides information on three aspects of the carcinogenic risk assessment for the agent in question: the USEPA classification and quantitative estimates of exposure. The classification reflects a weight-of-evidence judgment of the likelihood that the agent is a human carcinogen. The quantitative risk estimates are presented in application of a low-dose extrapolation procedure and presented as the risk per mg/kg-day. The unit risk is the quantitative estimate in terms of either risk per μg/L drinking water or risk per μg/m^3 air breathed. The third form in which risk is presented is drinking water or air concentration providing cancer risks of 1 in 10,000 or 1 in 1,000,000. The Carcinogenicity Background Document provides details on the carcinogenicity values found in IRIS. Users are referred to the Oral Reference Dose and Reference Concentration sections for information on long-term toxic effects other than carcinogenicity.

As listed in IRIS (search date June 28, 1995), the basis for the dibenz(a,h)anthracene and benzo(b)fluoranthene B2 classification is no human data and sufficient data from animal bioassays. Benzo(b)fluoranthene produced tumors in mice after lung implantation, intraperitoneal or subcutaneous injection, and skin painting. As listed in IRIS (search date June 28, 1995), the basis for the benzo(a)anthracene B2 classification is no human data and sufficient data from animal bioassays. Benzo(a)anthracene produced tumors in mice exposed by gavage; intraperitoneal, subcutaneous or intramuscular injection; and topical application. Benzo(a)anthracene produced mutations in bacteria and in mammalian cells, and transformed mammalian cells in culture. As listed in IRIS (search date June 28, 1995) the basis for the benzo(k)fluoranthene B2 classification is no human data and sufficient data from animal bioassays. Benzo(k)fluoranthene produced tumors after lung implantation in mice and when administered with a promoting agent in skin-painting studies. Equivocal results have been found in a lung adenoma assay in mice. Benzo(k)fluoranthene is mutagenic in bacteria. (Klaassen, et al., 1986).

Other PAHs — those not classified by USEPA as carcinogens — are toxic to the liver, kidney and blood. This group of PAHs includes compounds such as pyrene, acenaphthene, acenaphthylene, benzo(g,h,i)perylene, and phenanthrene. USEPA determined RfDs for only two of these compounds: pyrene's RfDo of 0.03 mg/kg-day is also used as a surrogate RfDo for phenanthrene. The RfDo for acenaphthene was 0.06 mg/kg-day.

Lead has been classified as a group B2 carcinogen by USEPA based on animal data. No RfD or SF has been set by USEPA. However, an action level for soil protective of child residents has been proposed by USEPA Region IV, 400 mg/kg. USEPA's OSWER has recommended a 1,000 mg/kg cleanup standard for industrial properties. USEPA's Office of Water has established a treatment technique action level of 15 μg/L. As listed in IRIS (search date October 17, 1995), the basis for classification is sufficient animal evidence. Ten rat bioassays and one mouse assay have shown statistically significant increases in renal tumors with dietary and subcutaneous exposure to several soluble lead salts. Animal assays provide reproducible results in several laboratories, in multiple rat strains with some evidence of multiple tumor sites. Short- term studies show that lead affects gene expression. Human evidence is inadequate. An RfD and SF have not been set because of the confounding nature of lead toxicity. Lead can accumulate in bone marrow, and effects have been observed in the CNS, blood, and mental development of children. RfDs are based on the assumption that a threshold must be exceeded to result in toxic effects (other than carcinogenicity). Once lead accumulates in the body, other influences cause the actual levels in the blood to fluctuate – sometimes the lead is attached to binding sites; sometimes lead is free flowing. If an exposed individual has previously been exposed to lead, this individual could lose weight and set fat-bound lead free. This fluctuation and lack of previous lead exposure data are two of the reasons lead effects are difficult to predict (Klaassen, et al., 1986).

Beryllium exposure via the inhalation route can cause inflammation of the lungs, a condition known as Acute Beryllium Disease, as a result of short-term exposure to high concentrations. Removal from exposure results in a reversal of the symptoms. Chronic exposure to much lower levels of beryllium or beryllium oxide by inhalation has been reported to cause chronic beryllium disease, with symptoms including shortness of breath, scarring of the lungs, and berylliosis, which is noncancerous growths in the lungs of humans. Both forms of beryllium disease can be fatal, depending on the severity of the exposure. Additionally, a skin allergy may develop when soluble beryllium compounds come into contact with the skin of sensitized individuals (Gradient, 1991). An oral RfD of 0.0054 mg/kg-day has been set for beryllium based on a chronic oral bioassay (rats were the study species) which determined no adverse effect occurs at 0.54 mg/kg-day. Beryllium has been classified by USEPA as a group B2 carcinogen based on animal studies. It has been shown to induce lung cancer via inhalation in rats and monkeys, and to induce osteosarcomas in rabbits via intravenous or intramedullary injection. Human epidemiology studies of beryllium are considered to be inadequate. As listed in IRIS (search date June 28, 1995), the basis for the classification is that beryllium has been shown to induce lung cancer via inhalation in rats and monkeys and to induce osteosarcomas in rabbits via intravenous or intramedullary injection. Human epidemiology studies are considered inadequate. An inhalation slope factor of 8.4 $(mg/kg\text{-}day)^{-1}$ and an oral SF of 4.3 $(mg/kg\text{-}day)^{-1}$ have been set by USEPA. As listed in IRIS (search date June 28, 1995), the critical effect of this chemical is no adverse effect. The uncertainty factor was 100 and the modifying factor was 1. The IRIS RfD in drinking water is 0.005 mg/kg-day.

Copper is a nutritionally essential element, necessary for many of the body's enzymes. In the past, lead pipes and solder were used for residential water pipes, and resulting lead concentrations in drinking water exceeded the guidelines set by the EPA. Copper has been used to replace water pipes in residences due to its lower toxicity to man. Short-term exposure to copper can result in anemia (the lack of iron), the breakdown of red blood cells, and liver and kidney lesions. The target organs for copper are the liver, kidney, and red blood cell. Vitamin C reduces copper uptake from the gut, and other substances can also influence copper uptake. Copper fumes can cause metal fume fever (Klaassen, et al., 1986). As listed in IRIS (search date June 28, 1995), the basis for the D classification is no human data, inadequate animal data from assays of copper compounds, and equivocal mutagenicity data. The RfD set by the EPA is 0.0371 mg/kg-day, which is 2.6 mg/day for the average adult (70 kg). In typical vitamin supplements, 2 mg/day is the approximate dose (NRC, 1989).

Chlordane is a polycyclic chlorinated pesticide. Acute exposure to high doses of chlordane causes tremors and convulsions. Chronic exposure can cause emotional and neuromuscular disturbances. Exposed individuals revert to normal approximately one week after the source is removed (Dreisbach, et al., 1987). USEPA has established an oral RfD of 6E-5 mg/kg-day and an oral SF of 1.3 $(mg/kg\text{-}day)^{-1}$.

10.6.5.4.5 Risk Characterization

Surface Soil Pathways

Exposure to surface soil onsite was evaluated under both residential and industrial (site worker) scenarios. For these scenarios, the incidental ingestion and dermal contact exposure pathways were evaluated. For noncarcinogenic contaminants evaluated for future site residents, hazard was computed separately to address child and adult exposure. Tables 10.6.5.13 and 10.6.5.14 present the computed carcinogenic risk and the HQ associated with the incidental ingestion of and dermal contact with site surface soils, respectively.

Hypothetical Site Residents

The ingestion ILCR (based on the adult and child lifetime weighted average) for AOC 518 for surface soil is 2E-6 and the dermal pathway ILCR is 8E-7. The computed HIs for the adult and child resident are 0.05 and 0.5, respectively for the soil ingestion pathway. The dermal contact pathway HIs are 0.02 and 0.07 for the adult resident and the child resident, respectively. Chlordane and beryllium were the contributors to the cumulative ILCR projections and chlordane was the primary contributor to HIs.

Table 10.6.5.13
Hazard Quotients and Incremental Lifetime Cancer Risks
Incidental Surface Soil Ingestion
AOC 518 Zone C
Naval Base Charleston
Charleston, SC

Chemical	Oral RfD Used (mg/kg-day)	Oral SF Used (mg/kg-day)-1	Potential Future Resident adult Hazard Quotient	Potential Future Resident child Hazard Quotient	Potential Futur Resident lwa ILCR	Potential Curren Worker adult Hazard Quotient	Potential Current Worker adult ILCR
Benzo(a)pyrene Equivale	NA	7.3	ND	ND	2.2E-07	ND	2.5E-08
Chlordane	6E-05	1.3	0.017	0.16	1.5E-06	0.006	1.7E-07
Aluminum	1	NA	0.014	0.13	ND	0.005	ND
Beryllium	0.005	4.3	0.00001	0.0001	3.3E-07	4.8E-06	3.7E-08
Lead	NA	NA	ND	ND	ND	ND	ND
Copper	0.04	NA	0.022	0.21	ND	0.008	ND
SUM Hazard Index/ILCR			0.05	0.5	2E-06	0.02	2E-07

NOTES:

NA Not available
ND Not Determined due to lack of available information
lwa lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime excess Cancer Risk

Table 10.6.5.14
Hazard Quotients and Incremental Lifetime Cancer Risks
Dermal Contact With Surface Soil
AOC 518 Zone C
Naval Base Charleston
Charleston, SC

Chemical	Dermal Adjustment	Oral RfD Used (mg/kg-day	Oral SF Used (mg/kg-day)-1	Potential Future Resident adult Hazard Quotient	Potential Future Resident child Hazard Quotient	Potential Futu Resident lwa ILCR	Potential Curren Worker adult Hazard Quotient	Potential Current Worker adult ILCR
Benzo(a)pyrene Equiv	0.5	NA	14.6	ND	ND	1.0E-07	ND	4.1E-08
Chlordane	0.5	3E-05	2.6	0.014	0.046	6.8E-07	0.0099	2.8E-07
Aluminum	0.2	0.2	0	2.8E-03	0.0093	ND	2.0E-03	ND
Beryllium	0.2	0.001	21.5	2.8E-06	0.00001	3.7E-08	2.0E-06	1.5E-08
Lead	0.2	NA	NA	ND	ND	ND	ND	ND
Copper	0.2	0.008	NA	0.005	0.015	ND	0.0033	ND
SUM Hazard Index/ILCR				0.02	0.07	8E-07	0.015	3E-07

NOTES:

NA Not available
ND Not Determined due to lack of available information
lwa lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime excess Cancer Risk
- Dermal to absorbed dose adjustment factor is applied to adjust for Oral SF and RfD (i.e., the oral RfD is based on oral absorption efficiency which should not be applied to dermal exposure and dermal CDI)

Hypothetical Site Workers

Site worker ILCRs are 2E-7 and 3E-7 for the ingestion and dermal contact pathways, respectively. The HI for both pathways are less than 0.1. Chlordane was the primary contributor to cumulative ILCR projections.

The AOC 518 area is a gravel and asphalt parking area partially covered by Building M-1257. Current site users have minimal chance of exposure to affected surface soil. As a result, the risk/hazard projections discussed above are considered gross overestimates should existing site features be maintained under future use scenarios.

Lead Toxicity

At AOC 518, one surface soil sample contained lead at a concentration exceeding the residential cleanup goal of 400 mg/kg. The mean lead concentration at AOC 518 is 142.5 mg/kg. Because the mean falls below the residential cleanup goal, chronic exposures are not expected to pose a significant health threat.

COCs Identified

One COC was identified at AOC 518 based on cumulative (all pathway) risk and hazard projected for this site. USEPA has established a generally acceptable risk range of 1E-4 to 1E-6, and an HI threshold of 1.0 (unity). In this human health risk assessment, a COC was considered to be any chemical contributing to a cumulative risk level of 1E-6 or one whose HQ exceeded 0.1. For carcinogens, this approach is relatively conservative, because a cumulative risk level of 1E-4 (and individual ILCR of 1E-6) is recommended by USEPA Region IV as the trigger for establishing COCs. The COC selection algorithm presented was used to provide a more comprehensive evaluation of chemicals contributing to carcinogenic risk or noncarcinogenic hazard during the remedial goal options development process.

Surface Soils

Hypothetical Site Residents (Future Land Use)

Chlordane was identified as the sole pathway COC based on its contribution to cumulative ILCR projections.

Hypothetical Site Workers

No surface soil COCs were identified for this receptor group based on contributions to cumulative ILCR or HI.

The extent of the COC identified in surface soil is briefly discussed below. Chlordane was detected in only one sample (518SB00101) at a concentration (7.4 mg/kg) in excess of the residential RBC (0.49 mg/kg). This sample was collected from an area estimated to be beneath the former coal bin. Two additional detections were reported in samples 518SB004 (0.048 mg/kg) and 518SB006 (0.0625 mg/kg). The extent of significant impacts is generally limited to the immediate vicinity of former building (coal bin) foundations.

10.6.5.4.6 Risk Uncertainty

Characterization of Exposure Setting and Identification of Exposure Pathways

The potential for high bias is introduced through the exposure setting and pathway selection due to the highly conservative assumptions (i.e., future residential use) recommended by USEPA Region IV when assessing potential future and current exposure. The exposure assumptions made in the site worker scenario are highly protective and would tend to overestimate exposure. Current site workers are not exposed to site groundwater. Most of AOC 518 is covered by asphalt, thus limiting exposure to affected surface soil.

Current site workers could infrequently be exposed to surface soils during invasive activities such as excavation to repair utilities, etc. Site workers would not be expected, however, to work onsite in contact with the affected media for eight hours per day, 250 days per year, as assumed in the exposure assessment.

AOC 518 is located in an area currently designated for use as residential and community support according to base reuse plans. If this area were to be used as a residential site, the asphalt surface would be removed, and the surface soil conditions would likely change (i.e., the soils would then be covered with landscaping soil and/or a house). Consequently, exposure to current soil conditions would not be likely under a true residential scenario. These factors indicate that exposure pathways assessed in this human health risk assessment would generally overestimate the risk and hazard posed to current site workers and future site residents.

Determination of Exposure Point Concentrations

Fewer than 10 samples were analyzed for each of the COPCs identified. As a result, the maximum concentrations were used as EPC for exposure quantification. A hot-spot approach was used to derive FI/FC factors to modify the EPCs for BEQs, chlordane and beryllium. No modifications were made to the maximum concentrations of other COPCs.

Frequency of Detection and Spatial Distribution

Due to the small area of investigation and limited extent of some COPCs, a hot-spot approach was used to modify the EPCs for BEQs, chlordane and beryllium. No FI/FC factor was derived for aluminum, lead, or copper. The hot-spot evaluation considered the areal extent of specific chemical impacts relative to a standard one-half acre exposure range.

BEQs were detected in two of six samples analyzed (518SB002 and 518SB003), which were isolated to an area between and immediately adjacent to the footprints of former coal bins (estimated area approximately 2,000 square feet). Based on this conservative projection of the impacted fraction of a standard one-half acre evaluation area, an FI/FC factor of 0.1 was estimated. It was hypothesized that elevated BEQ concentrations could be associated with coal residuum located beneath the existing parking surface.

Chlordane was detected exclusively at locations 518SB001, 518SB004 and 518SB006 of the seven sampled. Sample 518SB00101 was the only one with a chlordane concentration in excess of the residential RBC. This detection was found immediately adjacent to or beneath the projected footprint of the former coal bins. Considering the footprint of former building M-1123 (700 square feet estimated) to represent the extent of significant chlordane concentrations, an FI/FC factor of 0.1 was conservatively estimated. The significantly elevated chlordane concentrations near the former building footprint could indicate an association with termite control applications prior to building demolition.

Beryllium was detected in one of nine samples collected (518SB005; 0.49 mg/kg). This sample was collected north of the former coal bins and represents the most distant of the samples from the suspect source area. Based on its extremely limited extent, an FI/FC factor of 0.1 was estimated. This factor was also supported by estimation of the area represented by this single detection (less than 1,500 square feet). Beryllium was also detected at background sampling locations, although detections were reported in less than 10% of these samples. Onsite concentrations were comparable (+/- the analytical detection limit) to those reported at background locations.

Quantification of Risk/Hazard

As indicated by the discussions above, the uncertainty inherent in the risk assessment process is great. In addition, many site-specific factors have affected the uncertainty of this assessment that would upwardly bias the risk and hazard estimates. Exposure pathway-specific sources of uncertainty are discussed below.

Soil

Of the CPSSs screened and eliminated from formal assessment, none was reported at a concentration close to its corresponding RBC. This minimizes the likelihood of potentially significant cumulative risk/hazard based on the eliminated CPSSs. Although the future land use at this site is not definitively known, both the worker and residential exposure scenarios were assessed in this BRA. As previously discussed, these scenarios would likely lead to overestimates of risk and/or hazard.

Concentrations of aluminum, arsenic, and manganese exceeded their corresponding RBCs, but did not exceed their corresponding reference concentrations. Wilcoxon rank sum test analysis, however, indicated that the overall concentration distribution for aluminum in AOC 518 surface soil was significantly higher than background. As a result, aluminum was retained for formal assessment.

10.6.5.4.7 Risk Summary

The risk and hazard posed by contaminants at AOC 518 were assessed for the hypothetical site worker and the hypothetical future site resident under reasonable maximum exposure assumptions. For surface soils, the incidental ingestion and dermal contact pathways were assessed in this HHRA. Table 10.6.5.15 presents the risk summary for each pathway/receptor group evaluated for AOC 518.

10.6.5.4.8 Remedial Goal Options

Soil

RGOs for carcinogens presented in Table 10.6.5.16 were based on the lifetime weighted average site resident exposure for surface soils. Hazard-based RGOs were calculated based on the hypothetical child resident, as noted in the corresponding table. No RGOs were calculated relative to site worker soil exposure pathways because no COCs were identified for this receptor group.

Table 10.6.5.15
Summary of Risk and Hazard for AOC 518
NAVBASE - Charleston Zone C
Charleston, South Carolina

Medium	Exposure Pathway	HI (Adult)	HI (Child)	ILCR (LWA)	HI (Worker)	ILCR (Worker)
Surface Soil	Incidental Ingestion	0.05	0.5	2E-06	0.02	2E-07
	Dermal Contact	0.021	0.07	8E-07	0.015	3E-07
Sum of All Pathways		0.07	0.6	3E-06	0.03	6E-07

Notes:
ND indicates not determined due to the lack of available risk information.
ILCR indicates incremental excess lifetime cancer risk
HI indicates hazard index

Table 10.6.5.16
Residential-Based Remedial Goal Options Surface Soil
AOC 518 Zone C
Naval Base Charleston
Charleston, South Carolina

Chemical	Slope Factor (mg/kg-day)-1	Reference Dose (mg/kg-day)	FI/FC Factor	Unadjusted EPC mg/kg	Hazard-Based Remedial Goal Options 3 mg/kg	1 mg/kg	0.1 mg/kg	Risk-Based Remedial Goal Options 1E-06 mg/kg	1E-05 mg/kg	1E-04 mg/kg	Background Concentration mg/kg
Chlordane	1.3	6E-05	0.1	7.4	ND	ND	ND	3.4	33.9	339	NA

NOTES:

EPC exposure point concentration
NA not applicable
ND not determined
- remedial goal options were based on the residential lifetime weighted average for carcinogens and the child resident for noncarcinogens

10.6.5.4.9 Corrective Measures

For AOC 518, soil was the only environmental medium investigated. Air, groundwater and sediment media were not addressed for this site; therefore, corrective measures are not considered for these media. The only COC identified for the surface soil is chlordane. Its occurrence was limited to the building footings indicating its use for pest control. No further action is recommended.

10.6.6 AOC 520 — Former Garbage House

AOC 520 was a garbage storehouse for the barracks from the 1920s until the 1940s. Currently, the site is an asphalt parking area just north of Building M-17. A CSI was performed at AOC 520 to identify impacts to soil resulting from the storage and handling of garbage onsite. Potential contaminants include VOCs, SVOCs, pesticides, and metals from domestic wastes.

10.6.6.1 Soil Sampling and Analysis

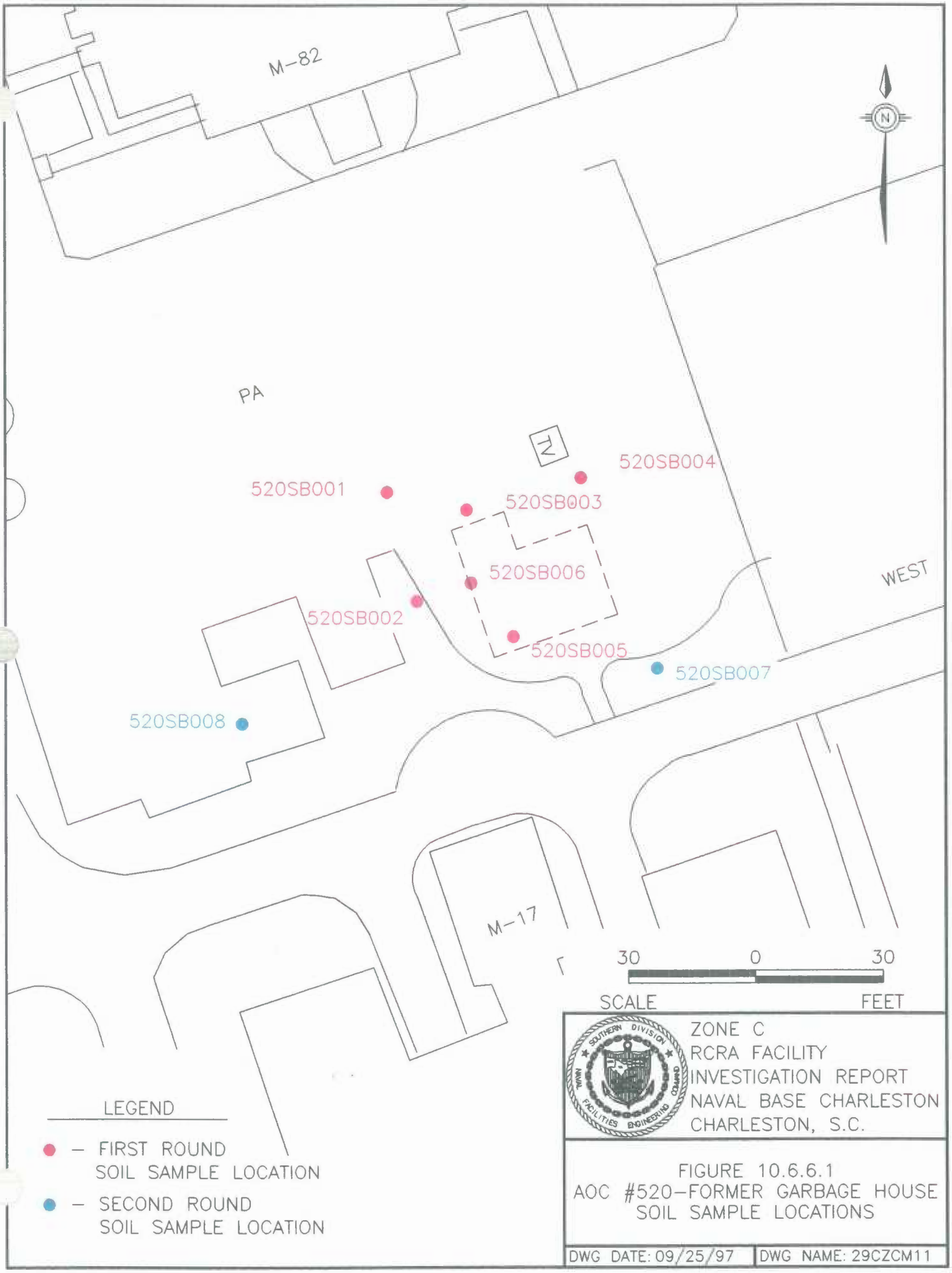
Soil was sampled in accordance with the *Final Zone C Work Plan*, (E/A&H, November 1995) and as outlined in Section 3 of this report. Sampling locations were selected following review of historical maps of the area and were placed at locations most likely impacted if a release had occurred. Figure 10.6.6.1 shows sample locations at AOC 520.

Soil was sampled in two rounds. Twelve soil samples were collected from six locations in the first round (one upper interval and one lower interval sample per location). First-round samples were analyzed for VOCs, SVOCs, pesticides/PCBs, metals, and cyanide at DQO Level III. One duplicate sample was collected and submitted for Appendix IX analyses at DQO Level IV. This includes the parameters listed above as well as herbicides, hexavalent chromium, organophosphorous pesticides, and dioxins. Table 10.6.6.1 summarizes the first round soil sampling and analysis.

Table 10.6.6.1
First Round — Soil Sampling and Analysis Summary
AOC 520 — Former Garbage House

Interval	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
Upper	6	6	Standard Suite[a]	Standard Suite[a]	None
Lower	6	6	Standard Suite[a]	Standard Suite[a]	None

Note:
[a] = Standard suite includes VOCs, SVOCs, metals, cyanide, and pesticide/PCBs.



LEGEND

- FIRST ROUND SOIL SAMPLE LOCATION
- SECOND ROUND SOIL SAMPLE LOCATION

ZONE C
RCRA FACILITY
INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 10.6.6.1
AOC #520–FORMER GARBAGE HOUSE
SOIL SAMPLE LOCATIONS

DWG DATE: 09/25/97 | DWG NAME: 29CZCM11

First round soil data were compared to the *USEPA Region III Risk-Based Concentration Table,* June 1996. This preliminary review indicated chlordane in four upper interval samples at concentrations exceeding the RBC of 490 μg/kg. The highest concentration was indicated at sample location 520SB005 at 1,400 μg/kg. During second-round sampling, two supplemental sample locations were added to the south of Building M-17 near location 520SB005 to delineate the extent of pesticide contamination. One upper interval sample was collected from each of the two locations and submitted for pesticide analyses. Table 10.6.6.2 summarizes the second round sampling and analysis.

Table 10.6.6.2
Second Round — Soil Sampling and Analysis Summary
AOC 520 — Former Garbage House

Interval	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
Upper	NA	2	NA	Pesticides	Two locations added

10.6.6.2 Nature and Extent of Soil Contamination

Soil analytical results for organics are in Table 10.6.6.3, and results for inorganics are in Table 10.6.6.4. Appendix D is a complete analytical report for Zone C, including AOC 520. Appendix H contains detection only summary tables.

Table 10.6.6.3
Organic Compound Analytical Results for Soil
AOC 520 — Former Garbage House

Compound	Sample Interval	Frequency of Detection	Range of Detection	Mean	RBC[a]	Number of Samples Exceeding RBC
Volatile Organic Compounds (μg/kg) **(Upper Interval — 6 Samples / Lower Interval — 6 Samples plus 1 Duplicate)**						
Methylene Chloride	Lower	1/6	37	NA	10	1

Table 10.6.6.3
Organic Compound Analytical Results for Soil
AOC 520 — Former Garbage House

Compound	Sample Interval	Frequency of Detection	Range of Detection	Mean	RBC[a]	Number of Samples Exceeding RBC
Semivolatile Organic Compounds (µg/kg) (Upper Interval — 6 Samples / Lower Interval — 6 Samples plus 1 Duplicate)						
Benzo(a)anthracene	Upper	1/6	170.0	NA	880[b]	0
Chrysene	Upper	1/6	170.0	NA	88,000[b]	0
di-n-Butylphthalate	Upper	1/6	45.0	NA	780,000	0
	Lower	1/6	91.0	NA	12,000	0
Fluoranthene	Upper	1/6	280.0	NA	310,000	0
Phenanthrene	Upper	1/6	120.0	NA	310,000	0
Pyrene	Upper	1/6	200.0	NA	230,000	0
BEQ	Upper	1/6	17.2	NA	88	0
Pesticide and PCB Compounds (µg/kg) (Upper Interval — 8 Samples / Lower Interval — 6 Samples plus 1 Duplicate)						
Chlordane	Upper	6/8	23.0 - 1,400	577.17	490	4
	Lower	4/6	23.0 - 290.0	145.25	2,000	0
delta-BHC	Upper	1/8	1.3	NA	350	0
beta-BHC	Upper	2/8	0.47 - 0.56	0.515	350	0
4,4-DDD	Upper	3/8	3.6 - 5.4	4.53	2,700	0
	Lower	1/6	12.0	NA	700	0
4,4-DDT	Upper	4/8	3.9 - 69.0	47.48	1,900	0
4,4-DDE	Upper	4/8	34.0 - 110.0	77.75	1,900	0
	Lower	1/6	19.0	NA	500	0
Dieldrin	Upper	2/8	2.5 - 8.4	5.45	40	0
Endosulfan I	Upper	1/8	4.2	NA	47,000	0
Endosulfan II	Upper	3/8	3.8 - 8.8	5.63	47,000	0
	Lower	2/6	3.7 - 4.0	3.85	300	0

Table 10.6.6.3
Organic Compound Analytical Results for Soil
AOC 520 — Former Garbage House

Compound	Sample Interval	Frequency of Detection	Range of Detection	Mean	RBC[a]	Number of Samples Exceeding RBC
Endosulfan sulfate	Upper	3/8	2.4 - 4.6	3.2	47,000	0
	Lower	2/6	2.1 - 4.8	3.45	300	0
Endrin	Upper	2/8	0.30 - 0.57	0.435	2,300	0
Endrin aldehyde	Upper	3/8	0.63 - 1.90	1.06	2,300	0
Heptachlor	Upper	3/8	0.52 - 8.5	3.47	140	0
	Lower	1/6	2.2	NA	60	0
Heptachlor epoxide	Upper	2/8	0.93 - 2.40	1.67	70	0
Methoxychlor	Lower	1/6	3.60	NA	62,000	0
Other Organic Compounds in Soil						
Dioxins in Soil (ng/kg) (Lower Interval — 1 Duplicate Sample)						
1234678-HpCDD	Lower	1/1	1.00	NA	NA	NA
1234678-HpCDF	Lower	1/1	1.22	NA	NA	NA
123478-HxCDF	Lower	1/1	0.139	NA	NA	NA
123678-HxCDF	Lower	1/1	0.254	NA	NA	NA
12378-PeCDD	Lower	1/1	0.209	NA	NA	NA
123789-HxCDF	Lower	1/1	0.317	NA	NA	NA
234678-HxCDF	Lower	1/1	0.13	NA	NA	NA
OCDD	Lower	1/1	4.38	NA	NA	NA
OCDF	Lower	1/1	2.32	NA	NA	NA
TEQ	Lower	1/1	.217	NA	80	0

Notes:
[a] = Noncarcinogenic RBCs were adjusted to equate to a hazard quotient of 0.1.
[b] = These compounds are cPAHs and were multiplied by the appropriate BEF for comparison as BEQs.
All results are in micrograms per kilogram (μg/kg) except dioxins which are in nanograms per kilogram (ng/kg).

Table 10.6.6.4
Inorganic Analytical Results for Soil
AOC 520 — Former Garbage House

Analyte	Sample Interval	Frequency of Detection[a]	Range of Detection (mg/kg)	Mean (mg/kg)	Reference Conc. (mg/kg)	Number of Samples Exceeding Reference
Aluminum	Upper	6/6	4,150.0 - 4,980.0	4,666.67	9,990	0
	Lower	6/6	2,050.0 - 3,960.0	2,896.67	23,700	0
Antimony	Upper	2/6	0.24 - 0.27	0.255	0.55	0
Arsenic	Upper	2/6	0.47 - 1.40	0.935	14.2	0
Barium	Upper	6/6	11.1 - 28.1	18.63	77.2	0
	Lower	6/6	4.6 - 13.5	6.90	68.5	0
Calcium	Upper	6/6	1,680.0 - 86,500	23,233.3	NA	0
	Lower	6/6	379.0 - 12,200	2,751.08	NA	0
Chromium	Upper	6/6	3.6 - 9.1	5.1	26.4	0
	Lower	6/6	2.4 - 4.3	3.52	12.5	0
Cobalt	Upper	5/6	0.39 - 10.3	4.078	3.22	2
	Lower	6/6	0.34 - 6.6	1.715	7.1	0
Copper	Upper	6/6	0.92 - 5.9	2.853	34.7	0
	Lower	6/6	0.55 - 1.10	0.757	42.2	0
Iron	Upper	6/6	1,920.0 - 4,220.0	2,406.67	NA	0
	Lower	6/6	802.5 - 1,950.0	1,255.42	NA	0
Lead	Upper	6/6	2.5 - 41.1	15.65	330	0
	Lower	6/6	1.8 - 3.4	2.35	73.2	0
Magnesium	Upper	6/6	224 - 2,490	854.83	NA	0
	Lower	6/6	80.8 - 455.0	194.3	NA	0
Manganese	Upper	6/6	15.2 - 71.2	33.93	92.5	0
	Lower	6/6	6.95 - 21.7	11.59	106	0
Nickel	Upper	6/6	1.5 - 8.2	3.05	12.3	0
	Lower	6/6	0.75 - 2.0	1.295	16.7	0
Potassium	Upper	6/6	90.8 - 1550	392.58	NA	0
	Lower	6/6	61.7 - 145.0	88.25	NA	0

Table 10.6.6.4
Inorganic Analytical Results for Soil
AOC 520 — Former Garbage House

Analyte	Sample Interval	Frequency of Detection[a]	Range of Detection (mg/kg)	Mean (mg/kg)	Reference Conc. (mg/kg)	Number of Samples Exceeding Reference
Selenium	Upper	2/6	0.48 - 0.57	0.525	1.44	0
	Lower	1/6	0.61	NA	2.90	0
Sodium	Upper	1/6	273.0	NA	NA	0
Tin	Upper	6/6	0.76 - 1.7	1.282	2.95	0
	Lower	6/6	0.91 - 1.7	1.308	2.37	0
Vanadium	Upper	6/6	2.7 - 7.7	3.967	23.4	0
	Lower	6/6	1.2 - 3.3	1.95	56.9	0
Zinc	Upper	6/6	4.8 - 33.0	17.67	159	0
	Lower	6/6	2.4 - 5.4	3.43	243	0

Volatile Organic Compounds in Soil

One VOC, methylene chloride, was detected in one lower interval soil sample (37 μg/kg) above its SSL (10 μg/kg).

Semivolatile Organic Compounds in Soil

Six SVOCs were detected in upper soil samples, and one SVOC (Di-n-butylphthalate) was detected in 520SB003 in the lower interval. Two of the SVOCs detected from one location (520SB001) are cPAHs. The BEQ calculated for sample 520SB00101 was 17.2 μg/kg, which is below the BaP RBC of 88 μg/kg. The lower interval detection of di-n-butylphthalate did not exceed its SSL.

Pesticides and PCBs in Soil

Fourteen pesticides were detected in upper interval soil samples, and eight were detected in lower interval soil samples. Chlordane was the only pesticide detected at four locations above its RBC of 490 μg/kg. All RBC exceedances were in upper interval soil samples. All detections were lower than the chlordane SSL of 2,000 μg/kg.

No PCB compounds were detected in the soil samples collected at AOC 520.

Other Organic Compounds in Soil

Other organic compounds include the Appendix IX compound groups that are not part of the standard analytical suite, including: herbicides, organophosphorous pesticides, and dioxins.

One herbicide was detected in the duplicate sample submitted for Appendix IX analyses; however, it was rejected due to QC parameters exceeding control limits. Organophosphorous pesticide compounds were not detected in the duplicate soil sample submitted for Appendix IX analyses. Nine dioxins were detected the duplicate sample submitted for Appendix IX analyses. The TEQ was calculated at 0.217 ng/kg. This is below the TCDD RBC of 1,000 ng/kg.

Inorganic Elements in Soil

Table 10.6.6.4 summarizes the inorganic analytical results for AOC 520. Nineteen inorganic analytes were detected in upper interval soil samples, and 15 were detected in lower interval samples. Cobalt was the only analyte detected above its reference concentration of 3.22 mg/kg. Two exceedances were in the upper interval. Cyanide was not detected in soil samples from AOC 520. Hexavalent chromium was not detected in the duplicate soil sample submitted for Appendix IX analyses from AOC 520.

10.6.6.3 Fate and Transport Assessment

AOC 520, a former garbage storehouse, currently is an asphalt parking area adjacent to Building M-17. Potential migration pathways for AOC 520 include constituents leaching from soil to groundwater and emission of volatile constituents from surface soil to air. Environmental media sampled as part of the AOC 520 RFI include surface soil and subsurface soil.

10.6.6.3.1 Soil-to-Groundwater Cross-Media Transport

Table 10.6.6.5 compares the maximum detected concentrations of chemicals in AOC 520 soil to the greater of risk-based soil screening levels considered protective of groundwater or background reference concentrations. No groundwater was sampled as part of the AOC 520 RFI. As a result no qualitative screening was performed. Three constituents (cobalt, dieldrin, and methylene chloride) were detected in AOC 520 soil above the groundwater protection SSLs or background reference concentrations. Dieldrin was detected in only two of eight surface soil samples and was not detected in subsurface soil samples. These findings indicate a potential for isolated areas of dieldrin leaching from surface soil, but significant impact to the shallow groundwater is not expected. Methylene chloride was detected in one of six subsurface soil samples and was not detected in surface soil samples. These findings suggest a potential for limited leaching of methylene chloride to the shallow groundwater; however, widespread impacts to the shallow aquifer are not expected. Cobalt was detected in three of 14 soil samples collected for AOC 520 at concentrations above its background reference concentration. Subsurface cobalt levels were consistent with Zone C background, indicating no significant threat to shallow groundwater.

10.6.6.3.2 Soil-to-Air Cross-Media Transport

Table 10.6.6.6 lists the volatile organic compounds detected in surface soil samples collected at AOC 520, along with corresponding soil-to-air volatilization screening levels. The maximum surface soil concentration of no volatile organic compound exceeded its corresponding soil-to-air volatilization screening level. As a result, the soil-to-air migration pathway is not expected to be significant.

Table 10.6.6.5
Chemicals Detected in Surface Soil and Subsurface Soil
Comparison to Groundwater Protection SSLs and Background UTLs
VBASE-Charleston, Zone C, AOC 520
..arleston, South Carolina

Parameter	Surface Soil Maximum Conc.	Subsurface Soil Maximum Conc.	Ground Water Protection SSL or UTL *	Soil Units	Soil Conc. Exceeds SSL or UTL
Aluminum	4980	3960	23700	MG/KG	NO
Antimony	0.27	ND	0.55	MG/KG	NO
Arsenic	1.4	ND	29	MG/KG	NO
Barium	28.1	13.5	1600	MG/KG	NO
Benzo(a)pyrene Equivalents					
Benzo(a)anthracene	170	ND	2000	UG/KG	NO
Chrysene	170	ND	160000	UG/KG	NO
beta-BHC	0.56	ND	3	UG/KG	NO
delta-BHC	1.3	ND	3	UG/KG	NO
Chlordane	1400	290	10000	UG/KG	NO
Chromium	9.1	4.3	38	MG/KG	NO
Cobalt	10.3	6.6	7.1	MG/KG	YES
Copper	5.9	1.1	42.2	MG/KG	NO
4,4'-DDD	5.4	12	16000	UG/KG	NO
4,4'-DDE	110	19	54000	UG/KG	NO
4,4'-DDT	69	ND	32000	UG/KG	NO
ɿ-butylphthlate	45	91	2300000	UG/KG	NO
ldrin	8.4	ND	4	UG/KG	YES
Dioxin (TCDD TEQ)	ND	0.217	4000	PG/G	NO
Endosulfan	13.4	8.8	1800	UG/KG	NO
Endrin	0.57	ND	1000	UG/KG	NO
Endrin aldehyde	1.9	ND	1000	UG/KG	NO
Fluoranthene	280	ND	430000	UG/KG	NO
Heptachlor	8.5	2.2	23000	UG/KG	NO
Lead	41.1	3.4	330	MG/KG	NO
Manganese	71.2	21.7	106	MG/KG	NO
Methoxychlor	ND	3.6	160000	UG/KG	NO
Methylene chloride	ND	37	20	UG/KG	YES
Nickel	8.2	2	130	MG/KG	NO
Phenanthrene	120	ND	100000000	UG/KG	NO
Pyrene	200	ND	420000	UG/KG	NO
Selenium	0.57	0.61	5	MG/KG	NO
Tin	1.7	1.7	2.95	MG/KG	NO
Vanadium	7.7	3.3	600	MG/KG	NO
Zinc	33	5.4	1200	MG/KG	NO

* - See Table 6-2
NA - Not available
ND - Not detected
SSL - Groundwater protection soil screening level
UTL - Grid-based background upper tolerance limit
MG/KG - Milligram per kilogram
KG - Micrograms per kilogram

Table 10.6.6.6
Soil-to-Air Volatilization Screening Analysis
NAVBASE - Charleston Zone C, AOC 520
Charleston, South Carolina

VOCs	Maximum Concentratio in Surface Soil	Soil to Air SSL *	Units	Exceeds SSL
Methylene chloride	0.037	7	MG/KG	NO

* - Soil-to-air RBCs were obtained from USEPA Region III Risk-based Concentration Tables, October 1995.

10.6.6.4 Human Health Risk Assessment

10.6.6.4.1 Site Background and Investigative Approach

The purpose of the investigation at AOC 520 was the assessment of soil potentially affected by past site activities. AOC 520 was a garbage storehouse for the barracks from the 1920s until the 1940s. Currently the site is an asphalt parking area just north of Building M-17.

Eight soil samples were collected from the upper interval. Table 10.6.6.7 lists analytical methods used for the corresponding samples. The number of soil samples differs for various groups of compounds because specific groups were targeted at certain sample locations and/or sampling rounds. No groundwater sampling was performed in conjunction with AOC 520.

10.6.6.4.2 COPC Identification

Soil

Based on the screening comparisons described in Section 7 of this RFI and presented in Table 10.6.6.8, one surface soil COPC was identified: chlordane. No analytes were identified as COPCs based on the results of Wilcoxon rank sum test analyses.

10.6.6.4.3 Exposure Assessment

Exposure Setting

AOC 520 is currently a paved parking area just north of Building M-17. It was formerly used from the 1920s through the 1940s as a garbage storehouse for wastes from the barracks. AOC 520 is in an area slated to be used as residential and community support according to base reuse plans.

Potentially Exposed Populations

Potentially exposed populations are current and future site workers. Additional potentially exposed populations are hypothetical future site residents. Future site resident and worker

Table 10.6.6.7
Methods Run at AOC 520
Surface Soil

Site	Location	Metal	SVOA	VOA	Cn	Hexa	Diox	Oppe	Herb	Pest	Tph	Otin	Eng
520	B001	Y	Y	Y	Y					Y			
520	B002	Y	Y	Y	Y					Y			
520	B003	Y	Y	Y	Y					Y			
520	B004	Y	Y	Y	Y					Y			
520	B005	Y	Y	Y	Y					Y			Y
520	B006	Y	Y	Y	Y					Y			
520	B007									Y			
520	B008									Y			

METHODS:

Metal: TAL (Target Analyte List) Metals plus tin:
Methods: 6000/7000 Series
VOA: Volatile Organic Analysis: Method 8240
SVOA: Semi-volatile Organic Analysis: Method 8270
Cn: Cyanide (Soil: Method 9010, Water: Method 9012)
Hexa: Hexavalent Chromium: Method 7195
Diox: Dioxins
Oppe: Organophosphate Pesticides:
Method 8140
Herb: Chlorinated Herbicides: Method 8150
Pest: Chlorinated Pesticides: Method 8080
Tph: Total Petroleum Hydrocarbons
Otin: Organotin
Eng: Engineering Parameters

KEY:

Y: Analyzed for standard list
D: Duplicate Analysis
IR: Method 4181
DR: Extraction Method 3550, GC Method 8100
GR: Extraction Method 5030, GC Method 8015
Blank value indicates this method of analysis was not performed

Table 10.6.6.8
Summary of Chemicals Present in Site Samples, AOC 520
Surface Soil
NAVBASE - Charleston, Zone C
Charleston, South Carolina

NAME	CONC UNITS	FREQ	DETECTS Min	DETECTS Max	DETECTS Avg	SCREENING Value	SCREENING # Over	SCREENING Source	NON-DETECTS Min	NON-DETECTS Max	BACKGROUND Value	BACKGROUND # Over
Carcinogenic PAHs												
B(a)P Equiv.	UG/KG	1 - 6	17.17	17.17	17.17	88			1343.96	1427.5		
Benzo(a)anthracene	UG/KG	1 - 6	170	170	170.00	880		C	690	730		
Chrysene	UG/KG	1 - 6	170	170	170.00	88000		C	560	600		
Inorganics												
Aluminum (Al)	MG/KG	6 - 6	4150	4980	4666.67	7800		N			9990	
Antimony (Sb)	MG/KG	2 - 6	0.24	0.27	0.26	3.1		N	0.2	0.21	0.55	
Arsenic (As)	MG/KG	2 - 6	0.47	1.4	0.94	0.43	2	C	0.33	0.34	14.2	
Barium (Ba)	MG/KG	6 - 6	11.1	28.1	18.63	550		N			77.2	
Calcium (Ca)	MG/KG	6 - 6	1680	86500	23233.33	NA						
Chromium (Cr)	MG/KG	6 - 6	3.6	9.1	5.10	39		N			26.4	
Cobalt (Co)	MG/KG	5 - 6	0.39	10.3	4.08	470		N	0.65	0.65	3.22	2
Copper (Cu)	MG/KG	6 - 6	0.92	5.9	2.85	310		N			34.7	
Iron (Fe)	MG/KG	6 - 6	1920	4220	2406.67	NA		N				
Lead (Pb)	MG/KG	6 - 6	2.5	41.1	15.65	400		j			330	
Magnesium (Mg)	MG/KG	6 - 6	224	2490	854.83	NA						
Manganese (Mn)	MG/KG	6 - 6	15.2	71.2	33.93	180		N			92.5	
Nickel (Ni)	MG/KG	6 - 6	1.5	8.2	3.05	160		N			12.3	
Potassium (K)	MG/KG	6 - 6	90.8	1550	392.58	NA						
Selenium (Se)	MG/KG	2 - 6	0.48	0.57	0.53	39		N	0.45	0.49	1.44	
Sodium (Na)	MG/KG	1 - 6	273	273	273.00	NA			92.5	241		
Tin (Sn)	MG/KG	6 - 6	0.76	1.7	1.28	4700					2.95	
Vanadium (V)	MG/KG	6 - 6	2.7	7.7	3.97	55		N			23.4	
Zinc (Zn)	MG/KG	6 - 6	4.8	33	17.67	2300		N			159	
Chlorinated Pesticides												
beta-BHC	UG/KG	2 - 8	0.47	0.56	0.52	350		C	1	10		
delta-BHC	UG/KG	1 - 8	1.3	1.3	1.30	490		I	0.52	10		
Chlordane	UG/KG	6 - 8	23	1400	577.17	490	4	C	4.1	4.4		
4,4'-DDD	UG/KG	3 - 8	3.6	5.4	4.53	2700		C	3.6	35		
4,4'-DDE	UG/KG	4 - 8	34	110	77.75	1900		C	3.6	3.7		

Table 10.6.6.8
Summary of Chemicals Present in Site Samples, AOC 520
Surface Soil
NAVBASE - Charleston, Zone C
Charleston, South Carolina

NAME	CONC UNITS	FREQ	DETECTS Min	DETECTS Max	DETECTS Avg	SCREENING Value	SCREENING # Over	SCREENING Source	NON-DETECTS Min	NON-DETECTS Max	BACKGROUND Value	BACKGROUND # Over
4,4'-DDT	UG/KG	4 - 8	3.9	69	47.48	1900		C	3.5	3.7		
Dieldrin	UG/KG	2 - 8	2.5	8.4	5.45	40		C	0.83	15		
Endosulfan I	UG/KG	1 - 8	4.2	4.2	4.20	47000		N	0.77	15		
Endosulfan II	UG/KG	3 - 8	3.8	8.8	5.63	47000		g	1.9	3.7		
Endosulfan sulfate	UG/KG	3 - 8	2.4	4.6	3.20	47000		g	2.1	20		
Endrin	UG/KG	2 - 8	0.3	0.57	0.44	2300		N	2.6	25		
Endrin aldehyde	UG/KG	3 - 8	0.63	1.9	1.06	2300		h	1	10		
Heptachlor	UG/KG	3 - 8	0.52	8.5	3.47	140		C	0.54	10		
Heptachlor epoxide	UG/KG	2 - 8	0.93	2.4	1.67	70		C	0.54	10		
Semivolatile Organics												
Di-n-butylphthalate	UG/KG	1 - 6	45	45	45.00	780000		N	790	820		
Fluoranthene	UG/KG	1 - 6	280	280	280.00	310000		N	960	1000		
Phenanthrene	UG/KG	1 - 6	120	120	120.00	310000		f	640	690		
Pyrene	UG/KG	1 - 6	200	200	200.00	230000		N	760	810		

Notes:
- * Retained as a chemical of potential concern
- C The RBC is based on carcinogenic effects
- N The RBC is based on noncarcinogenic effects
- j Screening level is set equal to the soil action level
- l The RBC for gamma-BHC is used as a surrogate
- g The RBC for endosulfan Is used as a surrogate
- h The RBC for endrin is used as a surrogate
- f The RBC for fluoranthene is used as a surrogate

exposure scenarios were addressed in this risk assessment. The hypothetical future site worker scenario assumes continuous exposure to surface soil conditions. Current site workers' exposure would be less than that assumed for the hypothetical future site worker scenario because of their limited soil contact (the entire area is covered by asphalt or buildings) and the fact that groundwater is not currently used onsite. Therefore, future worker assessment is considered to be protective of current site users.

Exposure Pathways

Exposure pathways for the site workers are dermal contact and incidental ingestion of surface soil. The exposure pathways for future residential land use are the same as those for the future site worker. In addition, the hypothetical future site worker scenario assumes continuous exposure to surface soil conditions. Uniform exposure was assumed for all sample locations. Table 10.6.6.9 presents the justification for exposure pathways assessed in this human health risk assessment.

Exposure Point Concentrations

Upper confidence limits are calculated for datasets consisting of at least 10 samples. The maximum concentration of chlordane (1.4 mg/kg) was used as the soil pathway EPC, because fewer than 10 samples were collected from the upper interval. A hot spot approach was used to account for the limited extent of identified impacts. Although chlordane was detected in six of eight samples, only four locations (SB001, SB002, SB005, and SB006) had concentrations above the residential RBC.

Table 10.6.6.9
Exposure Pathways Summary — AOC 520
NAVBASE — Zone C
Charleston, South Carolina

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Current Land Uses			
Current Site Users/Maintenance	Air, Inhalation of gaseous contaminants emanating from soil	No	No significant VOC concentrations were reported in surface soils, and portions of the site area are paved/covered by buildings.
	Air, Inhalation of chemicals entrained in fugitive dust	No	Portions of the site area are paved/covered by buildings, which limits fugitive dust generation.
	Shallow groundwater, Ingestion of contaminants during potable or general use	No	Shallow groundwater is not currently used as a source of potable or non-residential water at AOC 520.
	Shallow groundwater, Inhalation of volatilized shallow groundwater contaminants	No	Shallow groundwater is not currently used as a source of potable or non-residential water at AOC 520.
	Soil, Incidental ingestion	No (Qualified)	Future land use assessment is considered to be protective of current receptors.
	Soil, Dermal contact	No (Qualified)	Future land use assessment is considered to be protective of current receptors.
Future Land Uses			
Future Site Residents (Child and Adult) and Future Site Worker	Air, Inhalation of gaseous contaminants emanating from soil	No	No significant VOC concentrations were reported in surface soils, and portions of the site area are paved/covered by buildings.
	Air, Inhalation of chemicals entrained in fugitive dust	No	Portions of the site area are paved/covered by buildings, which limits fugitive dust generation.
	Shallow groundwater, Ingestion of contaminants during potable or general use	No	No groundwater sampling was performed in conjunction with the 520 investigation.
	Shallow groundwater, Inhalation of volatilized contaminants during domestic use	No	No groundwater sampling was performed in conjunction with the 520 investigation.
	Soil, Incidental ingestion	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Soil, Dermal contact	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Wild game or domestic animals, Ingestion of tissue impacted by media contamination	No	Hunting/taking of game and/or raising livestock is prohibited within the Charleston, South Carolina, City Limits.
	Fruits and vegetables, Ingestion of plant tissues grown in media	No	The potential for significant exposure via this pathway is low relative to that of other exposure pathways assessed.

An FI/FC term of 0.2 was applied to the EPC based on an impacted area of approximately 3,600 square feet, within a standard exposure range of one-half acre. The detections were focused around the footprint of former building M-1051.

Quantification of Exposure

Soil

Chronic daily intakes for ingestion and dermal contact with soils are shown in Tables 10.6.6.10 and 10.6.6.11, respectively.

10.6.6.4.4 Toxicity Assessment

Toxicity assessment terms and methods are discussed in Section 7 of this report. Table 10.6.6.12 presents toxicological information specific to the only COPC (chlordane) identified at AOC 520. This information was used in the quantification of risk/hazard associated with soil contaminants. A brief toxicological profile for chlordane is provided in the following paragraph.

Chlordane is a polycyclic chlorinated pesticide. Acute exposure to high doses of chlordane causes tremors and convulsions. Chronic exposure can cause emotional and neuromuscular disturbances. Exposed individuals revert to normal approximately one week after the source is removed (Dreisbach, et al., 1987). USEPA has established an oral RfD of 6E-5 mg/kg-day and an oral SF of 1.3 $(mg/kg\text{-}day)^{-1}$.

10.6.6.4.5 Risk Characterization

Surface Soil Pathways

Exposure to surface soil onsite was evaluated under both residential and industrial (site worker) scenarios. For these scenarios, the incidental ingestion and dermal contact exposure pathways were evaluated. For noncarcinogenic contaminants evaluated for future site residents, hazard was

Table 10.6.6.10
Chronic Daily Intakes (CDI)
Incidental Ingestion of Surface Soil (0-1')
AOC 520 Zone C
Naval Base Charleston
Charleston, SC

Chemical	TEF	Fraction Ingested fro Contaminate Source	Exposure Point Concentration (mg/kg)	Potential Future Resident adult H-CDI (mg/kg-day)	Potential Future Resident child H-CDI (mg/kg-day)	Potential Futur Resident lwa C-CDI (mg/kg-day)	Potential Curren Worker adult H-CDI (mg/kg-day)	Potential Current Worker adult C-CDI (mg/kg-day)
Chlordane	NA	0.2	1.400	3.84E-07	3.58E-06	4.38E-07	1.37E-07	4.89E-08

NOTES:

TEF toxic equivalency factor relative to Benzo(a)pyrene
lwa lifetime weighted average, used to calculate carcinogenic CDI, RAGS Parts A and B
CDI Chronic Daily Intake in mg/kg-day
H-CDI CDI for hazard quotient
C-CDI CDI for excess cancer risk
* Reflects the estimated fraction of the site impacted by the corresponding COPC.

Table 10.6.6.11
Chronic Daily Intakes (CDI)
Dermal Contact with Surface Soil (0-1')
AOC 520 Zone C
Naval Base Charleston
Charleston, SC

Chemical	TEF	Adjusted Exposure Point Concentration (mg/kg)	Fraction Contacted fro Contaminated Source *	Dermal Absorption Factor (unitless)	Potential Future Resident adult H-CDI (mg/kg-day)	Potential Future Resident child H-CDI (mg/kg-day)	Potential Futur Resident lwa C-CDI (mg/kg-day)	Potential Curren Worker adult H-CDI (mg/kg-day)	Potential Current Worker adult C-CDI (mg/kg-day)
Chlordane	NA	1.400	0.2	0.01	1.57E-07	5.19E-07	9.84E-08	1.12E-07	4.01E-08

NOTES:

TEF Toxic Equivalency Factor relative to Benzo(a)pyrene
CDI Chronic Daily Intake in mg/kg-day
H-CDI CDI for hazard quotient
C-CDI CDI for excess cancer risk
- The dermal absorption factor was applied to the exposure point concentration to reflect the different trans-dermal migration of inorganic versus organic chemicals
* Reflects the estimated fraction of the site impacted by the corresponding COPC.

Table 10.6.6.12
Toxicological Database Informatio
for Chemicals of Potential Concer
AOC 520
NAVBASE Charleston, Zone C

Non-Carcinogenic Toxicity Data

Chemical	Oral Reference Dose (mg/kg/day)		Confidence Level	Critical Effect	Uncertainty Factor Oral	Inhalation Reference Dose (mg/kg/day)	Confidence Level	Critical Effect	Uncertainty Factor Inhalation
Chlordane	6E-05	a	L	liver hypertrophy		ND			ND

NOTES:

a Integrated Risk Information System (IRIS)
b Health Effects Assessment Summary Tables (HEAST)
c HEAST alternative method
d USEPA Region III Screening Tables
e EPA Environmental Criteria and Assessment Office - Cincinnati (provisional)
f Withdrawn from IRIS or HEAST
Toxicological data for naphthalene were used as surrogates for 2-methylnaphthalene.
NA Not applicable or not available
ND Not determined due to lack of information

Table 10.6.6.12
Toxicological Database Informatio
for Chemicals of Potential Concer
AOC 520
NAVBASE Charleston, Zone C

Carcinogenic Toxicity Data

Chemical	Oral Slope Factor [(mg/kg/day)]-1		Inhalation Slope Factor [(mg/kg/day)]-1	Weight of Evidence	Tumor Type
Chlordane	1.3	a	ND	B2	liver carcinoma

computed separately to address child and adult exposure. Tables 10.6.6.13 and 10.6.6.14 present the computed carcinogenic risk and the HQ associated with the incidental ingestion of and dermal contact with site surface soils, respectively.

Hypothetical Site Residents

The ingestion ILCR (based on the adult and child lifetime weighted average) for AOC 520 surface soil is 4E-7, and the dermal pathway ILCR is 2E-7. The computed HIs for the adult and child resident are 0.004 and 0.04, respectively, for the soil ingestion pathway. The dermal contact pathway HIs were 0.003 and 0.01 for the adult resident and the child resident, respectively. Chlordane was the sole contributor in each instance.

Hypothetical Site Workers

Site worker ILCRs are 4.0E-8 and 7E-8 for the ingestion and dermal contact pathways, respectively. The HIs for both pathways are less than 0.1. Chlordane is the sole contributor to ILCR.

The area is entirely covered by an asphalt parking lot. Current site users have little chance of exposure to affected surface soil. As a result, the risk/hazard projections discussed above are considered gross overestimates, should existing site features be maintained under future use scenarios.

COCs Identified

No COCs were identified for AOC 520. USEPA has established a generally acceptable risk range of 1E-4 to 1E-6, and a HI threshold of 1.0 (unity). In this human health risk assessment, a COC was considered to be any chemical contributing to a cumulative risk level of 1E-6 or one whose HQ exceeded 0.1. For carcinogens, this approach is relatively conservative, as a cumulative risk level of 1E-4 (and individual ILCR of 1E-6) is recommended by USEPA Region IV as the trigger

Table 10.6.6.13
Hazard Quotients and Incremental Lifetime Cancer Risks
Incidental Surface Soil Ingestion
AOC 520 Zone C
Naval Base Charleston
Charleston, SC

Chemical	Oral RfD Used (mg/kg-day)	Oral SF Used (mg/kg-day)-1	Potential Future Resident adult Hazard Quotient	Potential Future Resident child Hazard Quotient	Potential Futur Resident lwa ILCR	Potential Curren Worker adult Hazard Quotient	Potential Current Worker adult ILCR
Chlordane	6E-05	1.3	0.006	0.06	5.7E-07	0.0023	6.4E-08
SUM Hazard Index/ILCR			0.006	0.06	6E-07	0.002	6E-08

NOTES:

NA Not available
ND Not Determined due to lack of available information
lwa lifetime weighted average, used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime excess Cancer Risk

Table 10.6.6.14
Hazard Quotients and Incremental Lifetime Cancer Risks
Dermal Contact With Surface Soil
AOC 520 Zone C
Naval Base Charleston
Charleston, SC

Chemical	Dermal Adjustment	Oral RfD Used (mg/kg-day	Oral SF Used (mg/kg-day)-1	Potential Future Resident adult Hazard Quotient	Potential Future Resident child Hazard Quotient	Potential Futu Resident lwa ILCR	Potential Curren Worker adult Hazard Quotient	Potential Current Worker adult ILCR
Chlordane	0.5	3E-05	2.6	0.0052	0.017	2.6E-07	0.0037	1.0E-07
SUM Hazard Index/ILCR				0.005	0.02	3E-07	0.004	1E-07

NOTES:

NA Not available
ND Not Determined due to lack of available information
lwa lifetime weighted average, used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime excess Cancer Risk
\- Dermal to absorbed dose adjustment factor is applied to adjust for Oral SF and RfD (i.e., the oral RfD is based on oral absorption efficiency which should not be applied to dermal exposure and dermal CDI)

for establishing COCs. The COC selection algorithm presented was used to provide a more comprehensive evaluation of chemicals contributing to carcinogenic risk or noncarcinogenic hazard during the remedial goal options development process.

Surface Soils

Hypothetical Site Residents (future land use)

No COCs were identified for surface soil based on contributions to ILCR or HI.

Hypothetical Site Worker

No COCs were identified for surface soil based on contributions to ILCR or HI.

No extent discussions are warranted as no COCs were identified.

10.6.6.4.6 Risk Uncertainty

Characterization of Exposure Setting and Identification of Exposure Pathways

The potential for high bias is introduced through the exposure setting and pathway selection due to the highly conservative assumptions (i.e., future residential use) recommended by USEPA Region IV when assessing potential future and current exposure. The exposure assumptions made in the site worker scenario are highly protective and would tend to overestimate exposure. Current site workers are not exposed to site groundwater. Most of AOC 520 is covered by an asphalt surface, thus precluding exposure to affected surface soil.

Current site workers could infrequently be exposed to surface soils during invasive activities such as excavation to repair utilities, etc. Site workers would not be expected, however, to work onsite in contact with the affected media for eight hours per day, 250 days per year as assumed in the exposure assessment.

AOC 520 is in an area currently designated for use as residential and community support, according to base reuse plans. If this area were to be used as a residential site, the asphalt surface would be removed and the surface soil conditions would likely change (i.e., the soils would then be covered with landscaping soil and/or a house). Consequently, exposure to current soil conditions would not be likely under a true residential scenario. These factors indicate that exposure pathways assessed in this human health risk assessment would generally overestimate the risk and hazard posed to current site workers and future site residents.

Determination of Exposure Point Concentrations

No soil UCLs were calculated, because fewer than 10 samples were collected from AOC 520. The maximum concentration of chlordane was used as the EPC and modified in accordance with the hot-spot approach.

Frequency of Detection and Spatial Distribution

Chlordane, the sole COPC identified at AOC 520, was detected in six of eight surface soil samples collected. The maximum reported concentration for chlordane was 1.4 mg/kg. Since the highest concentrations were found near the footprint of the former foundation of the garbage house and because of the age of the building, it is suspected that the presence of chlordane in surface soil is associated with pre-treatment for termites. An FI/FC factor of 0.2 was derived to account for the limited areal extent of significant impacts, which was estimated at 3,600 square feet for concentrations in excess of the residential RBC.

Quantification of Risk/Hazard

As indicated by the discussions above, the uncertainty inherent in the risk assessment process is great. In addition, many site-specific factors have affected the uncertainty of this assessment that would upwardly bias the risk and hazard estimates. Exposure pathway-specific sources of uncertainty are discussed below.

Soil

Of the CPSSs screened and eliminated from formal assessment, none was reported at a concentration close to its corresponding RBC. This minimizes the likelihood of potentially significant cumulative risk/hazard based on the eliminated CPSSs. Concentrations of arsenic and manganese exceeded their corresponding RBCs, but did not exceed the corresponding reference concentrations. Therefore, they were eliminated from formal assessment based on comparisons to reference concentrations.

Although the future land use at this site is not definitively known, both the worker and residential exposure scenarios were assessed in this HHRA. As previously discussed, these scenarios would likely lead to overestimates of risk and/or hazard.

Central tendency analysis was not performed because under the conservative chronic exposure assumptions, the projected ILCR was less than the 1E-6 point of departure.

10.6.6.4.7 Risk Summary

The risk and hazard posed by chlordane at AOC 520 were assessed for the hypothetical site worker and the hypothetical future site resident under reasonable maximum exposure assumptions. For surface soils, the incidental ingestion and dermal contact pathways were assessed in this human health risk assessment. Table 10.6.6.15 presents the risk summary for each pathway/receptor group evaluated for AOC 520.

10.6.6.4.8 Remedial Goal Options

Soil

No RGOs were calculated for future site residents or site workers because no COCs were identified for either receptor group at AOC 520.

10.6.6.4.9 Corrective Measures

No further action is required based on the analytical results and risk assessment. No COCs were identified.

Table 10.6.6.15
Summary of Risk and Hazard for AOC 520
NAVBASE - Charleston Zone C
Charleston, South Carolina

Medium	Exposure Pathway	HI (Adult)	HI (Child)	ILCR (LWA)	HI (Worker)	ILCR (Worker)
Surface Soil	Incidental Ingestion	0.006	0.06	6E-07	0.002	6E-08
	Dermal Contact	0.005	0.02	3E-07	0.004	1E-07
Sum of All Pathways		0.01	0.08	8E-07	0.006	2E-07

Notes:
ND indicates not determined due to the lack of available risk information.
ILCR indicates incremental excess lifetime cancer risk
HI indicates hazard index
LWA indicates lifetime weighted average exposure

10.7 GRID-BASED SAMPLING

Systematic grid-based sampling was performed across Zone C to more fully characterize zone-wide soil and groundwater contamination, to supplement the biased site locations while delineating site boundaries, and to establish background *reference concentrations* for soil and groundwater quality. Initially, none of the grid-based points were designated as background locations; however, following statistical analysis, acceptable data were designated as background and were used to develop reference concentrations for site comparison within Zone C. Section 5 presents the methods and results for determining reference concentrations for soil and groundwater. This section reports the grid-based soil and groundwater analytical results.

10.7.1 Soil Sampling and Analysis

A grid using 400 foot nodes was superimposed over Zone C creating 37 grid sampling points (Figure 10.7.1) in accordance with the *Final Zone C RFI Work Plan* (E/A&H, November 1995). Soil was sampled in two rounds. During the first round, nine upper interval and four lower interval soil samples were collected and submitted for VOCs, SVOCs, pesticides/PBCs, metals, and cyanide at DQO Level III. Four duplicate samples (two upper and two lower interval) were submitted for Appendix IX analyses at DQO Level IV. This includes the parameters listed above as well as herbicides, hexavalent chromium, organophosphorous pesticides, and dioxins. Table 10.7.1 summarized the first-round grid soil sampling and analysis.

Table 10.7.1
First Round — Soil Sampling and Analysis
Zone C Grid Samples

Interval	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
Fill Soil Upper	8	9	Standard Suite[a], TPH	Standard Suite[a], TPH	One additional sample submitted for analysis.
Fill Soil Lower	8	4	Standard Suite[a], TPH	Standard Suite[a], TPH	Shallow water table; saturated soil samples were not submitted for analyses.
Other Soil Upper	29	28	Metals, Cyanide	Metals, Cyanide	One sample from this group was analyzed for standard suite.
Other Soil Lower	29	24	Metals, Cyanide	Metals, Cyanide	Shallow water table; saturated soil samples were not submitted for analyses.

Note:
[a] = Standard Suite includes VOCs, SVOCs, metals, cyanide, and pesticide/PCBs.

LEGEND

• – GRID BASED SAMPLE LOCATION

400 0 400

SCALE FEET

ZONE C
RCRA FACILITY
INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

10.7.1
ZONE C
GRID BASED SAMPLE LOCATIONS

DWG DATE: 10/09/97

DWG NAME: 29ZNCMW3

00072604Z

Second-round grid-samples were collected following comparison of first-round data to the USEPA Region III *Risk-Based Concentration Table*; June 1996. This preliminary review indicated possible impacts associated with four grid sampling locations. 4,4'-DDE and 4,4'-DDT were detected above their respective RBCs in the upper interval at grid sampling location GDCSB001. Four additional upper interval samples (GDCSB045, GDCSB046, GDCC0047, and GDCSB048) were collected around this location and were submitted for pesticide analysis. BaP was detected above its RBC in grid sample GDCSB01701, located near SWMU 47. No additional grid sampling points were added, rather supplemental sampling points were included as part of the SWMU 47 investigation to delineate SVOC contamination. Lead was detected in grid sample GDCSB015 above the screening level. Four upper interval samples were collected around this grid location and submitted for metals analysis.

Three sampling locations were added around Building 400 at the request of the SOUTHDIV Remedial Project Manager (RPM) because it was reported, that while constructing this building, workers encountered strong petroleum odors in the soil. Three sample locations were added (GDCSB038, GDCSB039, and GDCSB040) and upper and lower interval samples were collected from each location and submitted for the standard suite analyses. In addition, one duplicate sample was submitted for Appendix IX analyses at DQO Level IV. Table 10.7.2 summarizes the second-round sampling and analysis.

Table 10.7.2
Second Round — Soil Sampling and Analysis
Zone C Grid Samples

Interval	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
Upper (GDCSB001)	0	4	None	Pesticides	Supplemental sampling location.
Upper (GDCSB015)	0	4	None	Metals	Supplemental sampling location.

Table 10.7.2
Second Round — Soil Sampling and Analysis
Zone C Grid Samples

Interval	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
Upper (Bldg 400)	0	3	Standard Suite[a], TPH	Metals, Cyanide	Supplemental sampling location.
Lower (Bldg 400)	0	3	Standard Suite[a], TPH	Metals, Cyanide	Supplemental sampling location.

Note:
[a] = Standard Suite includes VOCs, SVOCs, metals, cyanide, and pesticide/PCBs.

10.7.2 Nature and Extent of Contamination in Soil

Soil analytical results for organics are in Table 10.7.3; results for inorganics are in Table 10.7.4. Appendix D is the complete analytical report for Zone C and includes soil analytical results for grid samples. Appendix H contains detection only summary tables.

Table 10.7.3
Organic Compound Analytical Results for Soil
Zone C Grid Sample Locations

Compound	Sample Interval	Frequency of Detection[a]	Range of Detection	Mean	RBC[a]	Number of Samples Exceeding RBC
Volatile Organic Compounds (μg/kg) (Upper Interval — 15 Samples plus 3 Duplicates / Lower Interval — 8 Samples plus 2 Duplicates)						
Acetone	Upper	3/15	12 - 35	23	780,000	0
	Lower	1/8	29	NA	800	0
Toluene	Upper	3/15	2.0	2.0	1,600,000	0
	Lower	1/8	1.0	NA	5,000	0
Methylene chloride	Lower	1/8	14.0	NA	10	1

Table 10.7.3
Organic Compound Analytical Results for Soil
Zone C Grid Sample Locations

Compound	Sample Interval	Frequency of Detection[a]	Range of Detection	Mean	RBC[c]	Number of Samples Exceeding RBC
Semivolatile Organic Compounds (μg/kg) (Upper Interval — 15 Samples plus 3 Duplicates / Lower Interval — 8 Samples plus 2 Duplicates)						
Anthracene	Upper	2/15	39.0 - 50.0	45.5	2,300,000	0
Benzo(g,h,i)perylene	Upper	3/15	95.0 - 160.0	128.33	230,000	0
	Lower	1/8	93.0	NA	98,000	0
Benzo(a)anthracene	Upper	6/15	50.0 - 330.0	172.17	880[b]	0
	Lower	3/8	130.0 - 180.0	150.0	700	0
Benzo(a)pyrene	Upper	7/15	66.0 - 330.0	177.29	88[b]	4
	Lower	2/8	120.0 - 150.0	135.0	700	0
Benzo(b)fluoranthene	Upper	7/15	49.0 - 720.0	277.0	880[b]	0
	Lower	2/8	180.0 - 240.0	210.0	4,000	0
Benzo(k)fluoranthene	Upper	7/15	52.0 - 730.0	288.86	8,800[b]	0
	Lower	2/8	96.0 - 200.0	148.0	4,000	0
bis(2-Ethylhexyl)phthalate	Upper	3/15	86.0 - 1,200.0	478.67	46,000	0
Butylbenzylphthalate	Upper	1/15	160.0	NA	1,600,000	0
Chrysene	Upper	6/15	76.0 - 390.0	177.5	8,800[b]	0
	Lower	3/8	96.0 - 190.0	148.67	1,000	0
Di-n-Butylphthalate	Upper	1/15	140.0	NA	780,000	0
	Lower	2/8	110.0 - 120.0	115.0	12,000	0
Fluoranthene	Upper	8/15	42.0 - 630.0	243.6	310,000	0
	Lower	3/15	180.0 - 360.0	300.0	980,000	0
Hydrazine,1,2-diphenyl	Lower	1/8	47.0	NA	NA	NA
Indeno(1,2,3-cd)pyrene	Upper	4/15	57.0 - 220.0	126.75	310,000	0
	Lower	1/8	82.0	NA	35,000	0
1-Methylnaphthalene	Lower	1/8	63.0	NA	3,000	0
Naphthalene	Upper	1/15	39.0	NA	230	0

Table 10.7.3
Organic Compound Analytical Results for Soil
Zone C Grid Sample Locations

Compound	Sample Interval	Frequency of Detection[a]	Range of Detection	Mean	RBC[a]	Number of Samples Exceeding RBC
Phenanthrene	Upper	5/15	83.0 - 310.0	190.6	230,000	0
	Lower	2/8	110.0 - 230.0	170.0	98,000	0
Pyrene	Upper	8/15	28.0 - 950.0	243.56	230,000	0
	Lower	3/8	270.0 - 330.0	290.0	140,000	0
BEQ	Upper	7/15	26.0 - 335.42	152.96	88	4
Pesticide and PCB Compounds (μg/kg) **(Upper Interval — 19 Samples plus 3 Duplicates / Lower Interval — 8 Samples plus 2 Duplicates)**						
Aldrin	Upper	6/19	0.5 - 1.7	1.25	38	0
	Lower	1/8	1.6	NA	5	0
alpha-BHC	Upper	1/19	0.12	NA	100	0
	Lower	2/8	2.4 - 5.4	3.9	0.4	2
beta-BHC	Upper	3/19	0.53 - 31.0	10.69	350	0
	Lower	2/8	1.3 - 2.4	1.85	2	1
delta-BHC	Upper	5/19	0.26 - 6.8	1.93	490	0
	Lower	1/8	9.8	NA	2	1
gamma-BHC	Upper	2/19	1.7 - 2.1	1.9	490	0
	Lower	1/8	1.3	NA	6	0
Chlordane	Upper	9/19	14.0 - 680.0	179.0	490	1
	Lower	2/8	400.0 - 2,800.0	1,600.0	2,000	1
4,4-DDD	Upper	10/19	1.4 - 1,000.0	107.21	2,700	0
	Lower	3/8	1.8 - 59.0	23.17	700	0
4,4-DDE	Upper	14/19	3.0 - 4,000.0	305.99	1,900	1
	Lower	4/8	11.0 - 110.0	42.5	500	0
4,4-DDT	Upper	12/19	5.5 - 3,900.0	357.77	1,900	1
	Lower	6/8	1.3 - 25.0	19.48	1,000	0
Dieldrin	Upper	8/19	0.53 - 51.0	11.08	40	1
	Lower	2/8	4.0 - 4.6	4.3	1	2

Table 10.7.3
Organic Compound Analytical Results for Soil
Zone C Grid Sample Locations

Compound	Sample Interval	Frequency of Detection[a]	Range of Detection	Mean	RBC[a]	Number of Samples Exceeding RBC
Endosulfan I	Upper	3/19	2.2 - 3.1	2.7	4,700	0
Endosulfan II	Upper	5/19	3.1 - 40.0	13.9	4,700	0
	Lower	2/8	0.21 - 14.0	7.11	300	0
Endosulfan sulfate	Upper	5/19	1.0 - 3.0	1.76	4,700	0
	Lower	1/8	7.9	NA	300	0
Endrin	Upper	6/19	1.30 - 24.0	8.74	230	0
	Lower	1/8	14.0	NA	400	0
Endrin aldehyde	Upper	8/19	0.43 - 22.0	7.17	230,000	0
	Lower	1/8	3.5	NA	400	0
Heptachlor	Upper	5/19	0.37 - 5.6	1.94	140	0
	Lower	1/8	0.059	NA	60	0
Heptachlor epoxide	Upper	10/19	0.21 - 10.0	2.7	70	0
	Lower	2/8	1.2 - 2.1	1.65	60	0
Methoxychlor	Upper	8/19	1.1 - 31.0	7.59	39,000	0
	Lower	2/8	3.4 - 6.4	4.9	62,000	0
Aroclor-1260	Upper	4/19	14 - 450	187.5	83	3
	Lower	2/8	69 - 1,800	934.5	8,200	0
Herbicide Compounds (μg/kg) (Upper Interval — 3 Duplicate Samples / Lower Interval — 2 Duplicate Samples)						
2,4,5-TP (Silvex)	Lower	1/8	11.0	NA	NA	NA
2,4,5-Trichlorophenoxyacetic acid	Upper	3/3	11.0 - 26.0	17.33	78,000	0
	Lower	1/1	57.0	NA	200	0
Dinoseb	Upper	1/3	12.0	NA	780	0

Table 10.7.3
Organic Compound Analytical Results for Soil
Zone C Grid Sample Locations

Compound	Sample Interval	Frequency of Detection[a]	Range of Detection	Mean	RBC[a]	Number of Samples Exceeding RBC
Dioxins in Soil (ng/kg) **(Upper Interval — 3 Duplicate Samples / Lower Interval — 2 Duplicate Samples)**						
1234678-HpCDD	Upper	2/3	16.763 - 323.041	169.902	NA	NA
	Lower	1/1	1.777	NA	NA	NA
1234678-HpCDF	Upper	2/3	6.036 - 63.001	34.519	NA	NA
	Lower	1/1	3.299	NA	NA	NA
123478-HxCDD	Upper	1/3	4.32	NA	NA	NA
123478-HxCDF	Upper	1/3	2.53	NA	NA	NA
	Lower	1/1	0.459	NA	NA	NA
1234789-HpCDF	Lower	1/1	0.194	NA	NA	NA
123678-HxCDD	Upper	1/3	7.37	NA	NA	NA
123678-HxCDF	Upper	1/3	6.81	NA	NA	NA
	Lower	1/1	0.408	NA	NA	NA
123789-HxCDD	Upper	1/3	9.82	NA	NA	NA
123789-HxCDF	Lower	1/1	0.41	NA	NA	NA
234678-HxCDF	Upper	1/3	1.574	NA	NA	NA
	Lower	1/1	0.314	NA	NA	NA
OCDD	Upper	2/3	155.45 - 1,953.282	1,054.367	NA	NA
	Lower	1/1	12.17	NA	NA	NA
OCDF	Upper	2/3	27.744 - 148.415	NA	NA	NA
	Lower	1/1	3.645	NA	NA	NA
TEQ	Upper	3/3	100 - 634	3.27	1,000	0
	Lower	1/1	22.8	NA	NA	NA
Organophosphorous Pesticide Compounds (μg/kg) **(Upper Interval — 3 Duplicate Samples / Lower Interval — 2 Duplicate Samples)**						
Disulfoton	Upper	1/3	4.5	NA	3,100	0
Dimethoate	Upper	1/3	5.0	NA	160	0

Table 10.7.3
Organic Compound Analytical Results for Soil
Zone C Grid Sample Locations

Compound	Sample Interval	Frequency of Detection[a]	Range of Detection	Mean	RBC[a]	Number of Samples Exceeding RBC
Methyl parathion	Upper	1/3	4.2	NA	2,000	0
TPH Analytical Results (mg/kg)						
TPH	Upper	6/8	6.30 - 858.0	255.30	100	2
	Lower	3/3	18.5 - 4,706.0	1,600.23	NA	NA

Notes:
[a] = Noncarcinogenic RBCs were adjusted to equate to a hazard quotient of 0.1.
[b] = These compounds are cPAHs and were multiplied by the appropriate BEF for comparison as BEQs.
All results are in micrograms per kilogram (μg/kg), except for TPH, which is in milligrams per kilogram (mg/kg), and dioxins, which are in nanograms per kilogram (ng/kg).

Table 10.7.4
Inorganic Analytical Results for Soil
Zone C Grid Sample Locations
(Upper Interval — 45 Samples plus 3 Duplicates / Lower Interval — 30 Samples plus 1 Duplicate)

Analytes	Sample Interval	Frequency of Detection	Range of Detection (mg/kg)	Mean (mg/kg)	Reference Conc. (mg/kg)	Number of Samples Exceeding Reference
Aluminum	Upper	45/45	2,110.0 - 9,720.0	4,975.89	9,990	0
	Lower	30/30	1,450.0 - 25,400.0	6,481.83	23,700	1
Antimony	Upper	16/45	0.260 - 1.4	0.42	0.55	2
	Lower	4/30	0.210 - 0.920	0.49	0.92	1
Arsenic	Upper	31/45	0.40 - 39.40	5.53	14.92	3
	Lower	14/30	0.36 - 31.60	6.60	14.1	2
Barium	Upper	45/45	4.4 - 193.0	27.58	77.2	3
	Lower	30/30	3.6 - 64.6	17.47	68.5	0
Beryllium	Upper	4/45	0.11 - 0.26	0.18	0.15	3
	Lower	4/30	0.24 - 0.98	0.67	0.98	1
Cadmium	Upper	7/45	0.16 - 0.65	0.38	0.65	1
	Lower	3/30	0.13 - 0.28	0.21	0.28	1

Table 10.7.4
Inorganic Analytical Results for Soil
Zone C Grid Sample Locations
(Upper Interval — 45 Samples plus 3 Duplicates / Lower Interval — 30 Samples plus 1 Duplicate)

Analytes	Sample Interval	Frequency of Detection	Range of Detection (mg/kg)	Mean (mg/kg)	Reference Conc. (mg/kg)	Number of Samples Exceeding Reference
Calcium	Upper	44/45	449.0 - 85,600.0	15,675.30	NA	0
	Lower	26/30	93.8 - 40,300.0	5,202.72	NA	0
Chromium	Upper	45/45	2.7 - 31.8	9.76	26.4	1
	Lower	30/30	2.0 - 39.8	9.51	12.5	4
Cobalt	Upper	42/45	0.18 - 2.90	1.03	3.22	0
	Lower	25/30	0.14 - 7.10	1.34	7.1	1
Copper	Upper	44/45	0.81 - 39.70	11.46	34.7	2
	Lower	23/30	0.35 - 31.50	5.84	42.2	0
Iron	Upper	45/45	841.0 - 12,000.0	3,795.58	NA	0
	Lower	30/30	726.0 - 36,700.0	5,636.77	NA	0
Lead	Upper	45/45	2.70 - 588.0	68.46	330	2
	Lower	30/30	1.90 - 94.60	13.96	73.2	1
Magnesium	Upper	45/45	130.0 - 2,390.0	564.87	NA	0
	Lower	30/30	62.20 - 3,940.0	584.22	NA	0
Manganese	Upper	45/45	10.40 - 101.00	42.30	92.5	1
	Lower	30/30	3.20 - 520.00	53.61	106.0	2
Mercury	Upper	15/45	0.11 - 0.75	0.19	0.24	2
	Lower	6/30	0.14 - 8.50	1.60	0.30	2
Nickel	Upper	40/45	0.54 - 27.70	4.02	12.3	1
	Lower	21/30	0.57 - 12.50	3.13	16.7	0
Potassium	Upper	45/45	64.60 - 836.00	252.32	NA	0
	Lower	30/30	41.30 - 2,460.0	344.11	NA	0
Selenium	Upper	27/45	0.48 - 1.30	0.70	1.44	0
	Lower	12/30	0.49 - 2.90	1.08	2.90	1
Silver	Upper	3/45	0.05 - 0.06	0.057	ND	3

Table 10.7.4
Inorganic Analytical Results for Soil
Zone C Grid Sample Locations
(Upper Interval — 45 Samples plus 3 Duplicates / Lower Interval — 30 Samples plus 1 Duplicate)

Analytes	Sample Interval	Frequency of Detection	Range of Detection (mg/kg)	Mean (mg/kg)	Reference Conc. (mg/kg)	Number of Samples Exceeding Reference
Sodium	Upper	19/45	98.60 - 729.0	305.77	NA	0
	Lower	12/30	107.0 - 2,160.0	345.25	NA	0
Thallium	Lower	1/30	0.93	NA	ND	1
Tin	Upper	34/45	0.70 - 8.10	1.72	2.95	2
	Lower	16/30	0.64 - 2.00	1.29	2.37	0
Vanadium	Upper	45/45	2.70 - 25.40	8.81	23.4	2
	Lower	30/30	1.50 - 56.90	10.78	56.9	1
Zinc	Upper	45/45	3.40 - 779.0	74.72	159	2
	Lower	30/30	13.0 - 168.0	29.90	243	0

Volatile Organic Compounds in Soil

Three VOCs were detected in grid soil samples; however, they were below their respective RBCs for surface soil. One VOC, methylene chloride, was detected above its SSL (10 μg/kg) at one location.

Semivolatile Organic Compounds in Soil

Seventeen SVOCs were detected in grid soil samples including 15 in the upper interval and 13 in the lower interval. All SVOCs in the lower interval were below their respective SSLs; however, one compound, BaP, exceeded its RBC of 88 μg/kg at four locations in the upper interval (GDCSB005, GDCSB013, GDCSB039, and GDCSB040). The BEQs calculated for the upper interval ranged from 26.0 to 335.42 μg/kg, where the RBC for BaP was exceeded at the four locations listed above.

Pesticide/PCB Compounds in Soil

Twenty pesticides were detected in grid soil samples, 19 in the upper interval and 19 in the lower interval. Four of the pesticides in the upper interval, chlordane — 4,4'-DDE, 4,4'-DDT, and dieldrin — exceeded their RBCs at one location each (chlordane-GDCSB039, 4,4'-DDE-GDCSB001, 4,4'-DDT- GDCSB001, dieldrin-GDCSB009). Four of the pesticides in the lower interval, chlordane, delta-BHC, beta-BHC, and alpha-BHC exceeded their SSLs at one location each. One pesticide, dieldrin, exceeded its SSL at two subsurface soil locations. Aroclor-1260 was detected in four upper interval soil samples, of which three were above the RBC of 88 μg/kg. It was also detected in two lower interval soil samples.

Other Organic Compounds in Soil

Other organic compounds include petroleum hydrocarbons and the Appendix IX compound groups that are not part of the standard analytical suite, including; herbicides, organophosphorous pesticides, and dioxins.

Three herbicides, 2,4,5-TP (Silvex), 2,4,5-trichlorophenoxyacetic acid (2,4,5-T), and dinoseb were detected in the duplicate soil samples submitted for Appendix IX analysis. 2,4,5-T was detected in three upper and one lower interval sample, but was below its RBC. Likewise, dinoseb was detected in the one upper interval sample and was below its RBC. 2,4,5-TP was detected in a lower interval sample.

Three organophosphorous pesticides — disulfoton, dimethoate, and methyl parathion — were detected in Appendix IX samples, but were below their RBCs.

Twelve dioxin compounds were detected among 10 upper interval and 9 lower interval samples. The values listed in Table 10.7.3 indicate the range of detection for the group of samples analyzed. Calculation of TEQ was based on detection in an individual sample. The TEQs calculated ranged from 100 to 634 ng/kg, with a mean TEQ of 327 ng/kg. All TEQs were below the TCDD RBC of 1,000 ng/kg.

Inorganic Elements in Soil

Twenty-three inorganic analytes were detected in upper interval soil samples; 23 were detected in lower interval samples. Table 10.7.4 summarizes the inorganic analytical results for the grid samples. Nine analytes exceeded their respective reference concentrations in the upper and lower interval; antimony, arsenic, beryllium, cadmium, chromium, lead, manganese, mercury, and vanadium. Other analytes detected above their reference concentration are: barium, copper, nickel, and tin in the upper interval and aluminum, cobalt, selenium, and thallium in the lower interval. No analyte exceeded its reference concentration at more than six grid sampling locations.

Cyanide was not detected in grid soil samples. Hexavalent chromium was not detected in duplicate grid soil samples.

Supplemental Sampling Sites

As described above, additional grid samples were collected at three locations following a preliminary review of first-round data. These areas include grid locations GDCSB001 and GDCSB015, and Building 400. Analytical results for second-round samples were incorporated in the discussion above; however, to adequately follow up the supplemental data, the nature and extent of each supplemental grid sampling location are discussed below.

GDCSB001 — Four additional upper interval samples were collected from around grid location GDCSB001 and submitted for pesticide analysis after 4,4'-DDE and 4,4'-DDT exceeded their RBCs in sample GDCSB00101. In addition, a duplicate sample (GDCCB045) was submitted for

Appendix IX analyses. Three SVOCs, 11 pesticides, and 17 inorganic analytes, were detected in second round samples, but all were below their respective RBC or reference concentrations.

GDCSB015 — Lead exceeded its action level (400 mg/kg) for first-round evaluation in grid sample GDCSB01501. Four additional upper interval samples were collected around this location and analyzed for metals. Second round results indicated antimony, manganese, and vanadium above their reference concentrations. The frequency and mean of the exceedances are: antimony — 3 out of 4 at 0.41 mg/kg, manganese — 4 out of 4 at 58.28 mg/kg, and vanadium — 4 out of 4 at 14.43 mg/kg.

10.7.3 Groundwater Sampling and Analysis

Grid-wells were installed at two locations in Zone C where one shallow and one deep well were installed at each location. Groundwater was sampled in accordance with the *Final Zone C Work Plan* (E/A&H November 1995) and Section 3 of this report. Groundwater samples were analyzed for VOCs, SVOCs, pesticide/PBCs, metals, and cyanide at DQO Level III. Detected concentrations in groundwater will be further evaluated based on additional groundwater data collected during the subsequent three quarters of sampling. The data are discussed in the Section 11. Table 10.7.5 summarizes the initial round sampling and analysis for groundwater.

Table 10.7.5
Groundwater Sampling and Analysis
Zone C Grid Well Samples

Interval	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
Shallow	2	2	Standard Suite[a]	Standard Suite[a]	None
Deep	2	2	Standard Suite[a]	Standard Suite[a]	None

Note:
[a] = Standard suite includes VOCs, SVOCs, metals, cyanide, and pesticide/PCBs.

10.7.4 Nature and Extent of Chemicals Detected in Groundwater

Groundwater analytical results for organics are in Table 10.7.6; results for inorganics are in Table 10.7.7. Appendix D is complete report of the analytical data for Zone C including groundwater results for grid wells. Appendix H contains detection only summary tables.

Table 10.7.6
Organic Compound Analytical Results for Groundwater
Zone C Grid Wells

Compound	Depth Interval	Frequency of Detection	Range of Detection (μg/L)	Mean (μg/L)	Tap Water[a] (μg/L)	Number of Samples Exceeding RBCs
Volatile Organic Compounds						
Methylene chloride	Deep	½	12.0	NA	4.1	1
Pesticides and PCBs						
4,4'-DDD	Shallow	½	0.016	NA	0.28	0
Dieldrin	Deep	½	0.006	NA	0.0042	1
Endrin	Shallow	½	0.014	NA	1.1	0

Table 10.7.7
Inorganics Analytical Results for Groundwater
Zone C Grid Wells

Compound	Depth Interval	Frequency of Detection	Range of Detection (μg/L)	Mean (μg/L)	Reference Conc. (μg/L)	Number of Samples Exceeding Reference
Aluminum	Shallow	2/2	63.9 - 620.0	341.95	410	1
Barium	Shallow	½	13.4	NA	16.7	0
Calcium	Shallow	2/2	35,200 - 128,000	81,600	NA	0
	Deep	2/2	44,800 - 101,000	72,900	NA	0

Table 10.7.7
Inorganics Analytical Results for Groundwater
Zone C Grid Wells

Compound	Depth Interval	Frequency of Detection	Range of Detection (μg/L)	Mean (μg/L)	Reference Conc. (μg/L)	Number of Samples Exceeding Reference
Chromium	Shallow	½	2.1	NA	1.99	1
Iron	Shallow	2/2	566.0 - 3,480	2,023	NA	0
	Deep	2/2	220.0 - 587.0	403.5	NA	0
Magnesium	Shallow	2/2	1,000 - 7,710	4,355.0	NA	0
	Deep	2/2	1,420 - 13,200	7,310.0	NA	0
Manganese	Shallow	2/2	30.4 - 527.0	278.70	608.0	0
	Deep	2/2	35.4 - 67.5	51.45	147	0
Nickel	Shallow	½	1.6	NA	3.59	0
Potassium	Shallow	2/2	560.0 - 5,380.0	2,970.0	NA	0
	Deep	2/2	918.0 - 11,200.0	6,059.0	NA	0
Sodium	Shallow	½	9,640.0	NA	NA	0
	Deep	2/2	8.200 - 181,000	94,600	NA	0
Vanadium	Shallow	½	1.9	NA	1.96	0
	Deep	½	0.43	NA	0.54	0
Zinc	Shallow	2/2	5.8 - 13.4	9.6	13.2	1

Volatile Organic Compounds in Groundwater

Only one VOC, methylene chloride, was detected in one deep groundwater sample. It was detected at 12.0 μg/L which is above the tap water RBC of 4.1 μg/L. According to the *National Functional Guidelines for Organic Data Review* (February 1994), methylene chloride is a common laboratory artifact. Therefore, its presence may not be due to site-related environmental impacts.

Whether the contaminant is site-related will be based on the quarterly groundwater sampling data, which is discussed in Section 11.

Semivolatile Organic Compounds in Groundwater

No SVOCs were detected in grid groundwater samples.

Pesticide/PCB Compounds in Groundwater

Three pesticides were detected in groundwater samples. 4,4'-DDD and endrin were detected in shallow grid well samples and dieldrin was detected in one deep grid well sample. All were below their tap water RBCs.

No PCB compounds were detected in grid groundwater samples.

Inorganic Analytes in Groundwater

Twelve inorganic analytes were detected in grid-well groundwater samples. Table 10.7.7 lists the inorganic analytical results for the grid wells. Twelve analytes were detected in shallow grid-well samples; seven were detected in deep grid-well samples. Aluminum, chromium, and zinc exceeded their respective reference concentrations in shallow grid-well samples.

10.8 AOC 522 — Former Grease and Wash Building

AOC 522 is the site of former Building 1252, a grease and wash building, located at the southeast corner of Building 198, near the loading docks. This site has been designated for a CSI. Potential contaminants include lead paint, solvents, and petroleum hydrocarbons. The addendum Work Plan was reviewed and approved.

10.8.1 Soil Sampling and Analysis

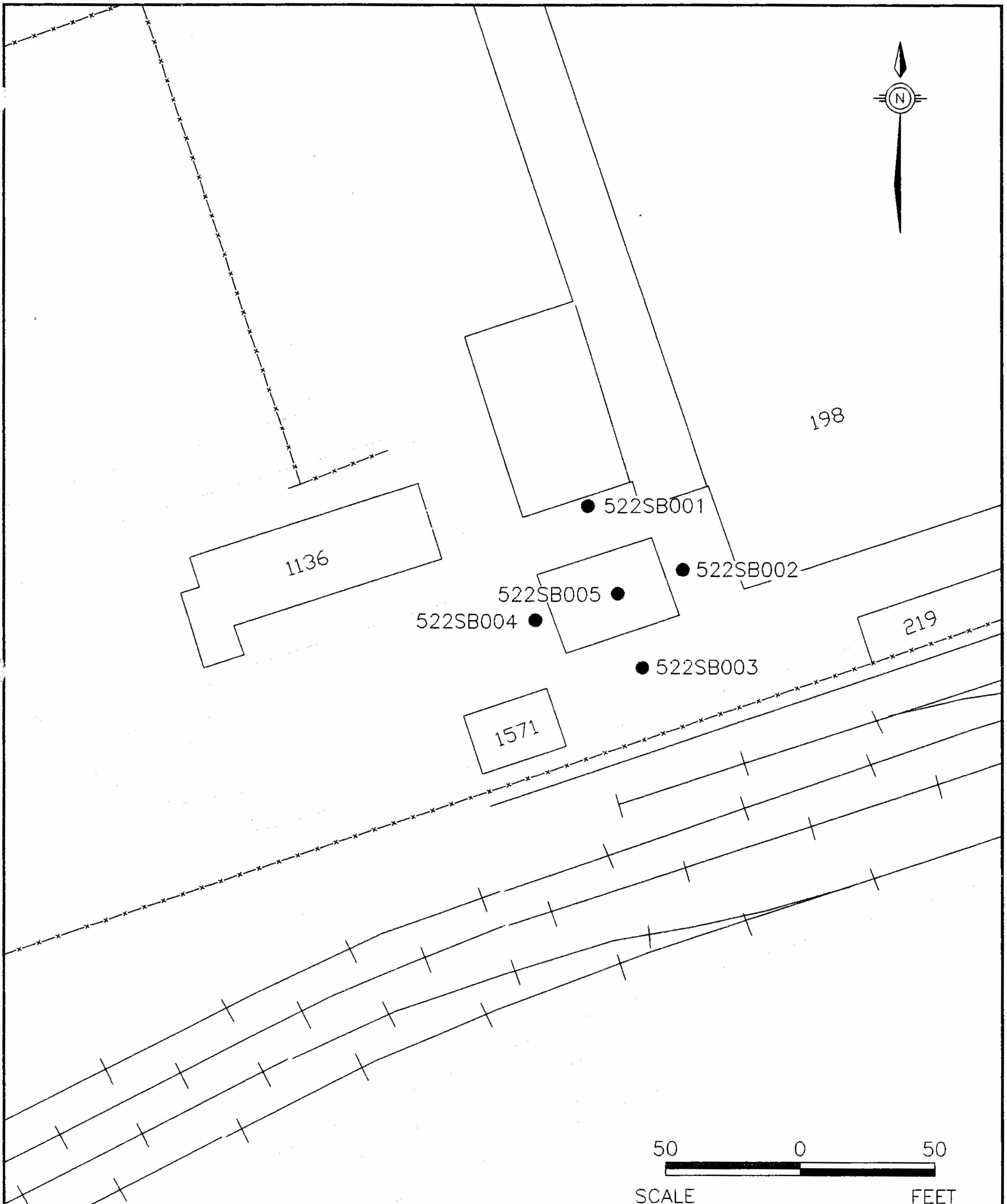
Soil sampling was conducted in accordance with the *Final Zone C Work Plan* (E/A&H, November 1995) and as outlined in Section 3 of this report. Sampling locations were selected following review of historical maps of the area and placed at locations most likely impacted if a release had occurred. Figure 10.8.1 shows soil sample locations.

Soil was sampled in one round at AOC 522, where ten soil samples were collected from five locations (one upper interval and one lower interval soil sample per location). Samples were analyzed for VOCs, SVOCs, pesticides/PCBs, metals, and cyanide at DQO Level III. One duplicate sample was collected and submitted for Appendix IX analyses at DQO Level IV. This includes the parameters listed above as well as herbicides, hexavalent chromium, organophosphorous pesticides, and dioxins. Table 10.8.1 summarizes the soil sampling and analysis.

Table 10.8.1
Soil Sampling and Analysis Summary
AOC 522 — Former Grease and Washing Building

Interval	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
Upper	5	5	Standard Suite[a]	Standard Suite[a]	None
Lower	5	5	Standard Suite[a]	Standard Suite[a]	None

Note:
[a] = Standard suite includes VOCs, SVOCs, metals, cyanide, and pesticides/PCBs.



ZONE C
RCRA FACILITY
INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 10.8.1
AOC #522
FORMER GREASE & WASH BUILDING
SAMPLING LOCATIONS

DWG DATE: 10/09/97 | DWG NAME: 29AOC522

Soil data were compared to the USEPA Region III *Risk-Based Concentration Table*; June 1996. This preliminary review indicated that additional sampling was not warranted at AOC 522.

10.8.2 Nature and Extent of Soil Contamination

Soil analytical results for organics are in Table 10.8.2, and results for inorganics are in Table 10.8.3. Appendix D contains a complete analytical report for Zone C, including AOC 522. Appendix H contains detection only summary tables.

Table 10.8.2
AOC 522 — Former Grease and Wash Building
Organic Compound Analytical Results for Soil

Compound	Sample Interval	Frequency of Detection	Range of Detection	Mean	RBC[a]	Number of Samples Exceeding RBC
Volatile Organic Compounds (μg/kg) (Upper Interval — 5 Samples, 1 Duplicate / Lower Interval — 5 Samples)						
Carbon Tetrachloride	Upper	1/5	1.0	NA	4,900	0
Methylene chloride	Upper	3/5	27.00 - 50.00	37.00	8,500	0
	Lower	4/5	9.00 - 40.00	25.25	10	3
Trichloroethene	Upper	3/5	3.00 - 8.00	5.00	12,000	0
Semivolatile Organic Compounds (μg/kg) (Upper Interval — 5 Samples, 1 Duplicate / Lower Interval — 5 Samples)						
Benzo(b)fluoranthene	Upper	1/5	54.00	NA	880	0
Chrysene	Upper	1/5	52.00	NA	88000	0
Phenanthrene	Upper	1/5	40.00	NA	310000	0
BEQ	Upper	1/5	5.45	NA	88	0
Pesticide and PCB Compounds (μg/kg) (Upper Interval — 5 Samples, 1 Duplicate / Lower Interval — 5 Samples)						
4,4-DDE	Upper	1/5	8.50	NA	19,000	0
4,4-DDT	Upper	1/5	3.40	NA	1,900	0
Heptachlor epoxide	Upper	1/5	2.30	NA	70	0

Table 10.8.2
AOC 522 — Former Grease and Wash Building
Organic Compound Analytical Results for Soil

Compound	Sample Interval	Frequency of Detection	Range of Detection	Mean	RBC[a]	Number of Samples Exceeding RBC
delta-BHC	Upper	1/5	3.00	NA	470	0
	Lower	1/5	3.00	NA	2	1
gamma-Chlordane	Upper	2/5	2.90 - 4.60	3.75	470	0
Dioxins (ng/kg) (Upper Interval — 1 Duplicate Sample)						
OCDD	1/5	Upper	8.64	NA	NA	0

Note:
All units are in micrograms per kilogram (μg/kg) except dioxins which are in nanograms per kilogram (ng/kg).

Table 10.8.3
AOC 522 — Former Grease and Wash Building
Inorganic Analytical Results for Soil

Analyte	Sample Interval	Frequency of Detection	Range of Detection (mg/kg)	Mean (mg/kg)	Reference Conc. (mg/kg)	Number of Samples Exceeding Reference
Aluminum	Upper	5/5	2,300 - 4,760	3,834.00	9,990	0
	Lower	5/5	1,300 - 6,150	2,988.00	23,700	0
Arsenic	Upper	5/5	2.8 - 4.35	3.45	14.2	0
	Lower	5/5	2.5 - 11.8	5.46	14.1	0
Beryllium	Upper	5/5	0.11 - 0.23	0.184	NA	0
	Lower	5/5	0.09 - 0.24	0.138	0.98	0
Cadmium	Upper	1/5	0.13	NA	0.65	0
Calcium	Upper	2/5	2,230 - 12,380	7,305.00	NA	0
Chromium	Upper	5/5	11.20 - 72.70	34.2	26.4	2
	Lower	5/5	8.20 - 17.20	11.52	NA	0
Cobalt	Upper	4/5	0.59 - 1.10	0.74	3.22	0
	Lower	1/5	0.41	NA	7.1	0
Copper	Upper	2/5	3.9 - 6.0	4.95	34.7	0
Cyanide	Upper	4/5	0.18 -0.27	0.1975	0.50	0
	Lower	1/5	0.19	NA	NA	0

Table 10.8.3
AOC 522 — Former Grease and Wash Building
Inorganic Analytical Results for Soil

Analyte	Sample Interval	Frequency of Detection	Range of Detection (mg/kg)	Mean (mg/kg)	Reference Conc. (mg/kg)	Number of Samples Exceeding Reference
Iron	Upper	5/5	2,730 - 4,810	3,443.00	NA	0
	Lower	5/5	2,540 - 5,960	3,898	NA	0
Lead	Upper	5/5	4.60 - 23.00	10.88	330	0
	Lower	5/5	1.60 - 4.50	2.66	73.2	0
Magnesium	Upper	5/5	480 - 2060	944.90	NA	0
	Lower	5/5	170 - 368	328.20	NA	0
Manganese	Upper	5/5	19.20 - 34.80	27.78	92.50	0
	Lower	4/5	8 - 22.40	12.45	106.0	0
Thallium	Lower	1/5	0.66	NA	ND	0
Vanadium	Upper	5/5	3.2 - 6.45	4.99	23.40	0
	Lower	5/5	3.9 - 12.90	7.24	56.9	0
Zinc	Upper	1/5	17.40	NA	159	0

Volatile Organic Compounds in Soil

Three VOCs were detected in soil samples: carbon tetrachloride, methylene chloride, and trichloroethene. All were below their respective RBCs. However, methylene chloride did exceed its SSL at three locations.

Semivolatile Organic Compounds in Soil

Three SVOCs were detected in soil samples: benzo(b)fluoranthene, chrysene, and phenanthrene. All were detected at concentrations below their respective RBCs. BEQs were calculated for the sample, and it was below the benzo(a)pyrene RBC of 88 μg/kg.

Pesticides and PCBs in Soil

Five pesticide compounds were detected in soil samples: 4-4'-DDE, 4,4'DDT, heptachlor epoxide, delta-BHC and gamma-Chlordane. All were detected below their respective RBCs in surface soil. However, one subsurface soil had detected delta-BHC above its SSL (2 μg/kg).

Other Organic Compounds in Soil

Other organic compounds include the Appendix IX compound groups that are not part of the standard analytical suite, including herbicides, organophosphorous pesticides, and dioxins.

No herbicide or organophosphorous pesticide compounds were detected in the duplicate soil sample submitted for Appendix IX analysis.

Four dioxins were detected in the duplicate sample from AOC 522. No RBCs apply to these parameters.

Inorganic Elements in Soil

Table 10.8.3 summarizes the inorganic analytical results for AOC 522. Fourteen inorganics were detected in upper interval soil samples, and 11 were detected in lower interval soil samples. One inorganic, chromium, was detected above its reference concentration for the upper interval. Chromium was detected in all upper interval samples with a range of 11.20 - 72.70 mg/kg and a mean of 34.26 mg/kg. Two samples (522SB001, 51.70 mg/kg and 522SB005, 72.70 mg/kg) exceeded the chromium reference concentration of 26.4 mg/kg.

Cyanide was detected in soil samples from AOC 522. Table 10.8.3 summarizes the cyanide analytical results for AOC 522. All samples were detected at concentrations below the respective RBC of 0.5 mg/kg. Hexavalent chromium was not detected in soil samples from AOC 522.

10.8.3 Fate and Transport Assessment

AOC 522 is the site of former Building 1252, a grease and wash building, at the southeast corner of Building 198, near the loading docks. Potential AOC 522 migration pathways include constituents leaching from soil to groundwater and emission of volatile constituents from surface soil to air. Environmental media sampled during the AOC 522 RFI included surface soil and subsurface soil.

10.8.3.1 Soil-to-Groundwater Cross-Media Transport

Table 10.8.4 compares the maximum detected concentrations of chemicals in AOC 522 soil to the greater of the groundwater protection SSLs or background reference concentrations. No groundwater was sampled as part of the AOC 522 RFI. However, data collected from downgradient AOC 523 monitoring wells were evaluated to assess impact to groundwater. Methylene chloride and chromium were detected in AOC 522 soil above the groundwater protection SSLs or background reference concentrations. Methylene chloride was detected in three of five surface soil samples and in four of five subsurface soil samples. These findings indicate a potential for isolated areas of methylene chloride leaching from soil, but significant impact to the shallow groundwater is not expected. Methylene chloride was also detected in several blanks associated with these soil samples, although strict application of data validation criteria did not result in U qualification of the results. These findings suggest a potential for limited leaching of methylene chloride to the shallow groundwater; however, widespread impacts to the shallow aquifer are not expected. Methylene chloride was not detected in downgradient AOC 523 wells indicating that the levels detected in soil are protective of groundwater.

Chromium was detected in a two samples (522001-01 and 522005-01) above its SSL of 38 mg/kg. The mean chromium concentration across the site was less than the SSL and at neither location was the subsurface soil result found to exceed the screening value. Based on these findings, it is not anticipated that existing chromium levels pose a significant threat to the shallow water-bearing zone.

Table 10.8.4
Chemicals Detected in Surface Soil and Subsurface Soil
Comparison to Groundwater Protection SSLs and Background UTLs
\VBASE-Charleston, Zone C, AOC 522
,arleston, South Carolina

Parameter	Surface Soil Maximu Conc.	Subsurface Soil Maximum Conc.	Ground Water Protection SSL or UTL *	Soil Units	Soil Conc. Exceeds SSL or UTL
Aluminum	4740	5120	23700	MG/KG	NO
Arsenic	4.3	11.8	29	MG/KG	NO
Benzo(a)pyrene Equivalents					
Benzo(b)fluoranthene	54	ND	5000	UG/KG	NO
Chrysene	52	ND	160000	UG/KG	NO
Beryllium	0.23	0.24	63	MG/KG	NO
delta-BHC	1.85	3	3	UG/KG	NO
Cadmium	0.125	ND	8	MG/KG	NO
Carbon tetrachloride	1	ND	70	MG/KG	NO
Chlordane	4.6	ND	10000	UG/KG	NO
Chromium	72.7	17.2	38	MG/KG	YES
Chromium (hexavalent)	ND	ND	38	MG/KG	NO
Cobalt	1.1	0.41	7.1	MG/KG	NO
Copper	6	ND	42.2	MG/KG	NO
4,4'-DDE	8.5	ND	54000	UG/KG	NO
4,4'-DDT	3.4	ND	32000	UG/KG	NO
Dioxin (TCDD TEQ)	0.0086	NA	4000	PG/G	NO
ɔtachlor epoxide	2.3	ND	700	UG/KG	NO
ɹd	23	4.5	330	MG/KG	NO
Manganese	34.8	22.4	106	MG/KG	NO
Methylene chloride	50	40	20	MG/KG	YES
Phenanthrene	40	ND	10000000	UG/KG	NO
Thallium	ND	0.66	0.7	MG/KG	NO
Trichloroethene	4	ND	60	MG/KG	NO
Vanadium	6.45	12.9	600	MG/KG	NO
Zinc	17.4	ND	1200	MG/KG	NO

* - See Table 6-2
NA - Not available
ND - Not detected
SSL - Groundwater protection soil screening level
UTL - Grid-based background upper tolerance limit
MG/KG - Milligram per kilogram
UG/KG - Micrograms per kilogram

10.8.3.2 Soil-to-Air Cross-Media Transport

Table 10.8.5 lists the volatile organic compounds detected in surface soil samples collected at AOC 522 along with corresponding soil-to-air volatilization screening levels. The maximum surface soil concentration of no volatile organic compound exceeded its corresponding soil-to-air volatilization screening level. As a result, the soil-to-air migration pathway is not expected to be significant.

10.8.4 Human Health Risk Assessment

10.8.4.1 Site Background and Investigative Approach

The purpose of the investigation at AOC 522 was the assessment of soil potentially affected by past site activities. AOC 522 is the former site of Building 1252, a grease and wash building, located at the southeast corner of Building 198, near the loading docks.

Five soil samples were collected from the upper interval. Table 10.8.6 lists analytical methods used for the corresponding samples. The number of soil samples differs for various groups of compounds because specific groups were targeted at certain sample locations and/or sampling rounds. No groundwater sampling was performed in conjunction with AOC 522.

10.8.4.2 COPC Identification

Soil

Based on the screening comparisons described in Section 7 of this RFI and presented in Table 10.8.7, two surface soil COPCs were identified: beryllium and chromium. No analytes were identified as COPCs based on the results of Wilcoxon rank sum test analyses.

Chromium was identified as a COPC based on comparison of the maximum reported surface soil concentration (72.7 mg/kg) to the residential RBC for hexavalent chromium (39 mg/kg). Hexavalent chromium analyses performed on one sample from AOC 522 were nondetect,

Table 10.8.5
Soil-to-Air Volatilization Screening Analysis
NAVBASE-Charleston, Zone C, AOC 522
Charleston, South Carolina

Parameter	Maximum Concentration in Surface Soil (mg/kg)	Soil to Air SSL *	Soil Units	Soil Conc. Exceeds SSL or UTL
Carbon tetrachloride	0.001	0.3	MG/KG	NO
Methylene chloride	0.05	13	MG/KG	NO
Trichloroethene	0.004	5	MG/KG	NO

* Soil to air SSLs were obtained from USEPA's Soil Screening Guidance: Technical Background Document, May 1996.

Table 10.8.6
Methods Run at AOC 522
Surface Soil

Site	Location	Metal	SVOA	VOA	CN	Hex-Cr	Diox	Herb	Pest	Oppe
522	B001	Y	Y	Y	Y				Y	
522	B002	Y	Y	Y	Y				Y	
522	B003	D	D	D	Y	Y	Y	Y	D	Y
522	B004	Y	Y	Y	Y				Y	
522	B005	Y	Y	Y	Y				Y	

Methods:
Metal - TAL (Target Analyte List) Metals plus tin; Methods 6000/7000 Series
SVOA - Semi-volatile Organics; Method 8270
VOA - Volatile Organics; Method 8240
CN - Cyanide (Soil: Method 9010)
Pest - Pesticides/PCBs; Method 8080
Hex-Cr - Hexavalent Chromium; Method 7195
Dioxin - Dioxin; Method 8290
Oppe - Organophosphate Pesticides: Method 8140
Herb - Chlorinated Herbicides: Method 8150

Key:
Y - Analyzed for standard list
D - Duplicate analysis

Table 10.8.7
AOC 522 - Former Building 1252
Surface Soil

Parameter	Units	Frequency of Detection	Range of Non detected Upper Bounds	Range of Detected Concentrations	Average Detected Conc.	Screening Conc.(s)	Num. Over Screen	Ref. Conc.	Num. Over Ref.
Aluminum	MG/KG	5 / 5		2300 - 4740	3834	7800		9990	
Arsenic	MG/KG	5 / 5		2.9 - 4.3	3.45	0.43	5	14.2	
Benzo(a)pyrene Equivalents	UG/KG	1 / 5		5.4 - 5.4	5.4	88			
Benzo(b)fluoranthene	UG/KG	1 / 5	350 - 560	54 - 54	54				
Chrysene	UG/KG	1 / 5	350 - 560	52 - 52	52				
* Beryllium	MG/KG	5 / 5		0.11 - 0.23	0.18	0.15	4	ND	
delta-BHC	UG/KG	1 / 5	1.4 - 1.6	1.85 - 1.85	1.85	490			
Cadmium	MG/KG	1 / 5	0.04 - 0.07	0.125 - 0.125	0.125	3.9		0.65	
Carbon tetrachloride	MG/KG	1 / 5	5 - 8	1 - 1	1	4.9			
gamma-Chlordane	UG/KG	2 / 5	1.4 - 1.6	1.8 - 4.6	3.2	490			
* Chromium	MG/KG	5 / 5		11.2 - 72.7	32.3	39	2	26.4	2
Chromium (hexavalent)	MG/KG	0 / 1	0.274 - 0.274			39		ND	
Cobalt	MG/KG	4 / 5	0.32 - 0.32	0.62 - 1.1	0.75	470		3.22	
Copper	MG/KG	2 / 5	1.1 - 1.8	2.42 - 6	4.2	290		42.2	
4,4'-DDE	UG/KG	1 / 5	2.7 - 4.2	8.5 - 8.5	8.5	1900			
4,4'-DDT	UG/KG	1 / 5	2.7 - 4.2	3.4 - 3.4	3.4	1900			
Dioxin (TCDD TEQ)	PG/G	1 / 1		0.009 - 0.009	0.009	1000			
Heptachlor epoxide	UG/KG	1 / 5	1.4 - 2.2	2.3 - 2.3	2.3	70			
Iron	MG/KG	5 / 5		2730 - 4810	3443				
Lead	MG/KG	5 / 5		4.6 - 23	10.3	400 j		330	
Manganese	MG/KG	5 / 5		19.2 - 34.8	27.8	180		92.5	
Methylene chloride	MG/KG	3 / 5	6 - 21	27 - 50	37	85			
Phenanthrene	UG/KG	1 / 5	350 - 560	40 - 40	40	310000 k			
Trichloroethene	MG/KG	1 / 5	5 - 8	4 - 4	4	58			
Vanadium	MG/KG	5 / 5		3.2 - 6.45	4.99	55		23.4	
Zinc	MG/KG	1 / 5	4 - 14.9	17.4 - 17.4	17.4	2300		159	

Notes:
* Retained as a chemical of potential concern
s USEPA Region III Residential Risk -Based Screening Value, January-June 1996
e Acenaphthene used as surrogate
f Fluoranthene used as surrogate
g Endosulfan used as surrogate
h Endrin used as surrogate
I Naphthalene used as surrogate
j Based on proposed action level for soil and treatment technique action level for water.
k Fluoranthene used as surrogate
l gamma-BHC used as surrogate

indicating that chromium exists predominantly in its trivalent form. A comparison of surface soil results to the trivalent chromium RBC (7,800 mg/kg) showed that existing surface soil levels should not pose a significant hazard. As a result, chromium was not carried forward to formal assessment.

Beryllium was detected in each surface soil sample ranging from 0.11 to 0.23 mg/kg with a mean of 0.18 mg/kg. Due to the number of nondetect reported for background locations, no reference concentration was computed. A review of background location surface soil data found concentrations ranging from nondetect to 0.26 mg/kg, with subsurface levels reaching nearly 1 mg/kg. Based on these findings, it was concluded that onsite beryllium results were comparable to those at background locations and did not reflect impacts associated with past site uses. As a result, beryllium was not retained as a COPC for AOC 522.

After consideration of site-specific valence for chromium and background beryllium levels, it was concluded that no surface soil COPCs existed and the site did not warrant formal assessment.

10.8.5 Corrective Measures Considerations

No further action is required based on the analytical results and risk assessment. No COCs were identified.

10.9 AOC 700 — Golf Course Maintenance Building

AOC 700 is the site of a golf course maintenance building, Building 1646, located west of Avenue "D" and north of Hunt Street. This site has been designated for an RFI. Potential contaminants include acids, solvents, herbicides, pesticides, and petroleum hydrocarbons.

10.9.1 Soil Sampling and Analysis

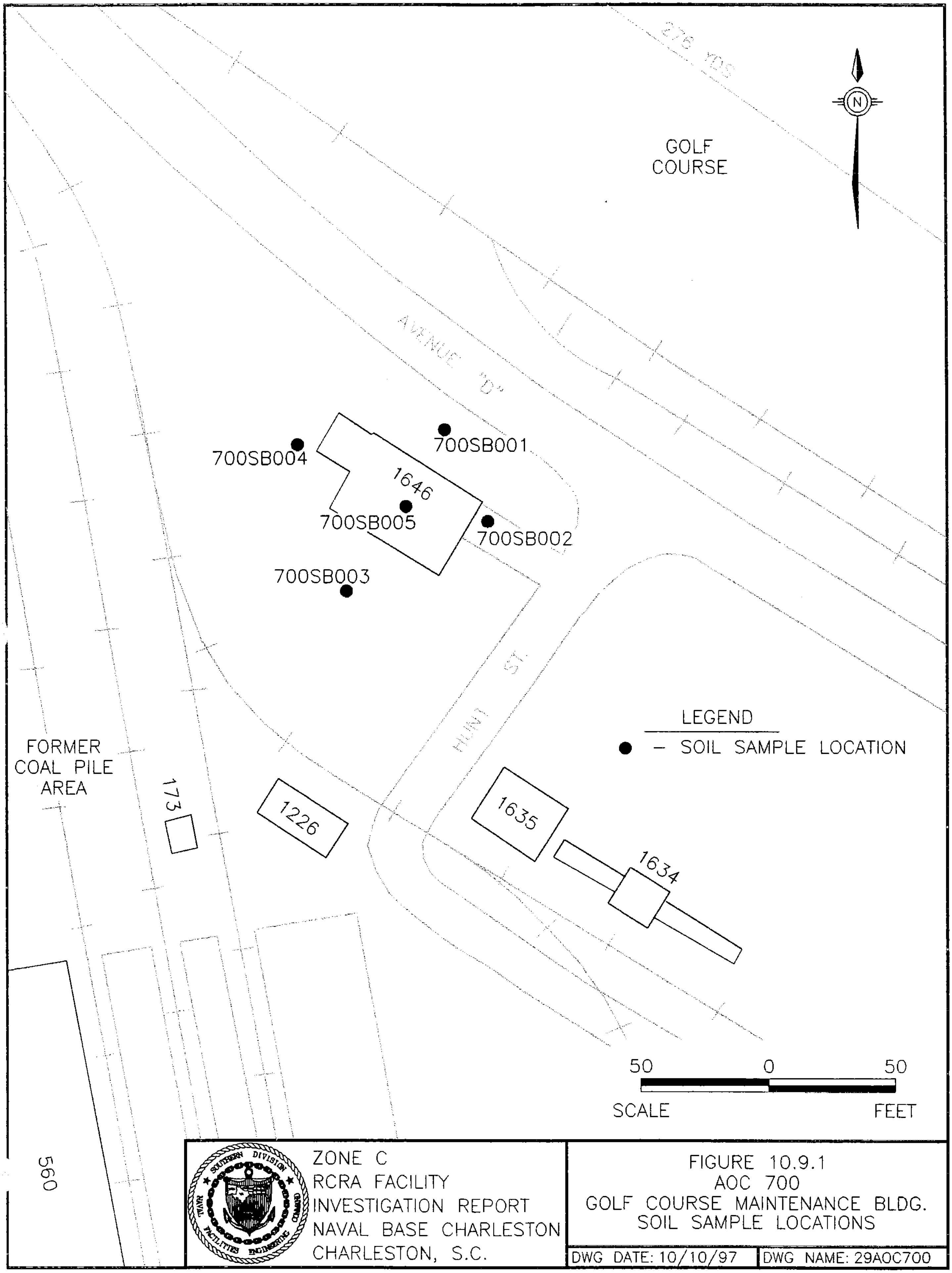
Soil was sampled in accordance with the *Final Zone C RFI Work Plan* (E/A&H, November 1995) and Section 3 of this report. Sample locations were selected following review of historical maps of the area and were placed at locations likely impacted if a release had occurred. Soil sample locations are shown on Figure 10.9.1.

Ten soil samples were collected in one round from five locations (one upper and one lower interval sample per location). Table 10.9.1 summarizes the soil sampling and analysis. Soil samples were analyzed for VOCs, SVOCs, pesticides/PCBs, metals, and cyanide at DQO Level III. One duplicate sample was collected and submitted for Appendix IX analyses at DQO Level IV. This includes the parameters listed above as well as herbicides, hexavalent chromium, organophosphorous pesticides, and dioxins.

Soil data were compared to the *USEPA Region III Risk-Based Concentration Table*, June 1996. Results of this preliminary review indicated no additional sampling was warranted at AOC 700.

10.9.2 Nature and Extent of Soil Contamination

Soil analytical results for organics are in Table 10.9.2, and results for inorganics are in Table 10.9.3. Appendix D is a complete analytical report for Zone C and includes the soil analytical results for AOC 700. Appendix H contains detection only summary tables.



ZONE C
RCRA FACILITY
INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 10.9.1
AOC 700
GOLF COURSE MAINTENANCE BLDG.
SOIL SAMPLE LOCATIONS

DWG DATE: 10/10/97 | DWG NAME: 29AOC700

Table 10.9.1
Soil Sampling and Analysis Summary
AOC 700 — Golf Course Maintenance Building

Interval	Samples Proposed	Samples Collected	Analyses Proposed	Analyses Performed	Deviations
Upper	5	5	Standard Suite[a]	Standard Suite[a]	None
Lower	5	5	Standard Suite[a]	Standard Suite[a]	None

Note:
[a] = Standard suite includes VOCs, SVOCs, metals, cyanide, and pesticide/PCBs.

Table 10.9.2
Organic Compound Analytical Results for Soil
AOC 700 — Golf Course Maintenance Building

Compound	Sample Interval	Frequency of Detection	Range of Detection	Mean	RBC[a]	Number of Samples Exceeding RBC
Volatile Organic Compounds (μg/kg) (Upper Interval — 5 Samples Plus 1 Duplicate / Lower Interval — 5 Samples)						
Trichloroethene	Upper	1/5	3.00	NA	58,000	0
	Lower	2/5	2.00-2.00	2.00	3,000	0
Semivolatile Organic Compounds (μg/kg) (Upper Interval — 5 Samples Plus 1 Duplicate / Lower Interval — 5 Samples)						
2-Methylnaphthalene	Upper	5/5	102.0-960.0	388.4	310,000	0
	Lower	5/5	46.0-210.0	102	3,000	0
4-Methylphenol (p-Cresol)	Upper	1/5	42.00	NA	39,000	0
Acenaphthene	Lower	1/5	460.0	NA	20,000	0
Acenaphthylene	Upper	1/5	57.0	NA	470,000	0
Anthracene	Upper	3/5	43.0-64.0	53.5	2,300,000	0
	Lower	1/5	58.0	NA	430,000	0
Benzo(a)anthracene	Upper	5/5	48.0 -140.0	109.6	880[b]	0
	Lower	4/5	53.0-72.0	60.5	700	0
Benzo(a)pyrene	Upper	5/5	51.0-230.0	108.2	88[b]	2
	Lower	3/5	50.0-64.0	55.33	4,000	0

Table 10.9.2
Organic Compound Analytical Results for Soil
AOC 700 — Golf Course Maintenance Building

Compound	Sample Interval	Frequency of Detection	Range of Detection	Mean	RBC[a]	Number of Samples Exceeding RBC
Semivolatile Organic Compounds ($\mu g/kg$) **(Upper Interval — 5 Samples Plus 1 Duplicate / Lower Interval — 5 Samples)**						
Benzo(b)fluoranthene	Upper	5/5	88.0-345.0	200.6	880[b]	0
	Lower	4/5	80.0-94.0	87.25	4,000	0
Benzo(g,h,i)perylene	Upper	4/5	47.0 - 160.0	86.5	31,000	0
Benzo(k)fluoranthene	Upper	5/5	56.0 -280.0	139.4	8,800[b]	0
	Lower	4/5	61.0-95.0	76.25	4,000	0
Benzoic Acid	Upper	2/5	61.0-78.0	69.5	31,000,000	0
	Lower	5/5	44.0-120.0	78.6	28,000	0
Chrysene	Upper	5/5	75.0 -340.0	208	8,800[b]	0
	Lower	4/5	91.0 - 120.0	112.75	1,000	0
Dibenz(a,h)anthracene	Upper	1/5	68.5	NA	88,000	0
Dibenzofuran	Upper	4/5	87.0 - 230.0	144.75	31,000	0
	Lower	1/5	130.0	130.0	12,000	0
Diethyphthalate	Upper	1/5	41.0	NA	6,300,000	0
Fluorene	Lower	1/5	120.0	NA	16,000	0
Indeno(1,2,30cd)pyrene	Upper	4/5	44.0 - 145.0	75	880	0
	Lower	2/5	44.0 - 45.0	44.5	35,000	0
Naphthalene	Upper	5/5	71.0 - 480.0	244.2	310,000	0
	Lower	4/5	49.0 - 160.0	85.25	3,000	0
Phenanthrene	Upper	5/5	102.5 - 550.0	338.5	230,000	0
	Lower	5/5	62.0 - 140.0	114.4	98,000	0
Pyrene	Upper	5/5	76.0 - 505.0	264.2	230,000	0
	Lower	4/5	94.0 - 190.0	136	140,000	0
BEHP	Upper	3/5	37.0-81.0	57	46,000	0
	Lower	2/5	51.0 - 54.0	52.5	11,000	0
BEQ	Upper	5/5	69.63 - 364.53	160.5	88	4

Table 10.9.2
Organic Compound Analytical Results for Soil
AOC 700 — Golf Course Maintenance Building

Compound	Sample Interval	Frequency of Detection	Range of Detection	Mean	RBC[a]	Number of Samples Exceeding RBC
Pesticide and PCB Compounds (µg/kg) (Upper Interval — 5 Samples Plus 1 Duplicate/Lower Interval — 5 Samples)						
alpha-Chlordane	Upper	2/5	2.2 - 3.15	2.68	490	0
gamma-Chlordane	Upper	2/5	3.4 - 6.5	4.95	490	0
4,4-DDD	Upper	1/5	9.70	NA	2,700	0
	Lower	2/5	8.10-13.0	10.55	700	0
4,4-DDT	Upper	4/5	18.0 - 77.0	35.25	1,900	0
	Lower	5/5	3.9 - 34.0	12.24	1,000	0
4,4-DDE	Upper	5/5	2.90 - 61.0	27.98	1,900	0
	Lower	4/5	4.0 - 25.0	10.13	500	0
Dieldrin	Upper	1/5	5.9	NA	40	0
	Lower	1/5	9.2	NA	1	1
Endrin	Upper	1/5	8.1	NA	2,300	0
Heptachlor	Upper	1/5	1.7	NA	140	0
Heptachlor epoxide	Upper	1/5	3.2	NA	70	0
Other Organic Compounds						
Dioxins in Soil (ng/kg) (Lower Interval — 1 Sample)						
1234678-HpCDD	Upper	1/1	147.0	NA	NA	NA
1234678-HpCDF	Upper	1/1	27.7	NA	NA	NA
123478-HxCDF	Upper	1/1	3.04	NA	NA	NA
OCDD	Upper	1/1	932.0	NA	NA	NA
OCDF	Upper	1/1	48.9	NA	NA	NA
TEQ	Upper	1/1	3.032	NA	1,000	0

Notes:
[a] = Noncarcinogenic RBCs were adjusted to equate to a hazard quotient of 0.1.
[b] = These compounds are cPAHs and were multiplied by the appropriate BEF for comparison as BEQs.
All results are in µg/kg except dioxin which is in ng/kg.

Table 10.9.3
Inorganic Analytical Results for Soil
AOC 700 — Golf Course Maintenance Building

Compound	Sample Interval	Frequency of Detection[a]	Range of Detection (mg/kg)	Mean (mg/kg)	Reference Conc. (mg/kg)	Number of Samples Exceeding Reference
Aluminum	Upper	5/5	2,650 - 3,450	3,100	9,990	0
	Lower	5/5	880.0 - 3,490	2,205	23,700	0
Antimony	Lower	1/5	4.7	4.7	0.92	1
Arsenic	Upper	5/5	3.0 - 14.3	7.71	14.2	1
	Lower	5/5	2.3 - 17.4	8.76	14.1	2
Beryllium	Upper	5/5	0.14 - 0.29	.21	NA	0
	Lower	5/5	0.1 - 0.73	.372	0.98	0
Cadmium	Upper	5/5	0.14 - 1.11	.526	0.65	1
	Lower	5/5	0.14 - 0.56	.278	0.28	2
Calcium	Upper	3/5	20,000 - 80,200	44,000	NA	0
	Lower	5/5	1,200 - 8,710	3,958	NA	0
Chromium	Upper	5/5	21.35 - 224.00	81.17	26.4	4
	Lower	5/5	28.6 - 280.0	116.42	12.5	5
Cobalt	Upper	5/5	0.64 - 2.50	1.81	3.22	0
	Lower	5/5	0.45 - 12.80	3.63	7.1	1
Copper	Upper	5/5	4.7 - 31.1	16.83	34.7	0
	Lower	5/5	13.8 - 92.40	42.7	42.2	2
Cyanide	Upper	4/5	.14 - .24	.19	ND	4
	Lower	4/5	.16 - .39	.26	ND	4
Iron	Upper	5/5	2,030 - 6,640	3,880	NA	0
	Lower	5/5	2,750 - 8,740	4,080	NA	0
Lead	Upper	5/5	27.5 - 55.3	41.49	330	0
	Lower	5/5	16.2 - 327.0	91.94	73.2	1
Magnesium	Upper	5/5	115.0 - 1,020	490.9	NA	0
	Lower	4/5	121.0 - 267.0	219.75	NA	0

Table 10.9.3
Inorganic Analytical Results for Soil
AOC 700 — Golf Course Maintenance Building

Compound	Sample Interval	Frequency of Detection[a]	Range of Detection (mg/kg)	Mean (mg/kg)	Reference Conc. (mg/kg)	Number of Samples Exceeding Reference
Manganese	Upper	5/5	25.8 - 71.4	45.59	92.5	0
	Lower	5/5	13.9 - 53.5	29.8	106	0
Mercury	Upper	1/5	0.04	.04	0.24	0
Nickel	Upper	2/5	6.75 - 6.8	6.78	12.3	0
	Lower	4/5	5.3 - 35.7	20.95	16.7	2
Selenium	Upper	1/5	1.6	1.6	1.44	1
	Lower	3/5	0.38 - 0.55	.45	2.90	0
Thallium	Upper	1/5	2.0	2.0	ND	1
Vanadium	Upper	5/5	4.1 - 9.9	6.2	23.4	0
	Lower	5/5	2.0 - 9.7	4.94	56.9	0
Zinc	Upper	5/5	89.5 - 309.0	168.62	159	2
	Lower	5/5	105.0 - 583.0	256.6	243	2

Volatile Organic Compounds in Soil

Trichloroethene was the only VOC detected in soil. It was below its RBC and SSL.

Semivolatile Organic Compounds in Soil

Twenty-one SVOCs were detected in soil samples from AOC 700; most were detected in two samples, 700SB00301 and 700SB00601. Except for benzo(a)pyrene, all of the SVOCs were detected below their respective RBCs. Benzo(a)pyrene exceeded its RBC at 700SB001 and 700SB003. SVOCs in subsurface soil were below their SSLs. BEQs exceeded its RBC of 88 μg/kg at four locations.

Pesticides and PCBs in Soil

Nine pesticide compounds were detected in soil samples from AOC 700; however, all were below their respective RBCs in surface soil. Dieldrin exceeded its SSL in one subsurface soil sample. No PCB compounds were detected in soil samples from AOC 700.

Other Compounds in Soil

Other compounds include the Appendix IX compound groups that are not part of the standard analytical suite, including herbicides, organophosphorous pesticides, hexavalent chromium, and dioxins.

Herbicides, organophosphorous pesticides, and hexavalent chromium were not detected at AOC 700.

Five dioxins were detected in the duplicate sample submitted for analysis. The TEQ calculated for this sample was 3.032 ng/kg, which is below the TDCC RBC of 1,000 ng/kg.

10.9.3 Nature and Extent of Groundwater Contamination

To evaluate the SSL exceedances in soil, groundwater sample collected at 044GW008 is evaluated for AOC 700. The monitoring well is approximately 50 feet downgradient of the site, and would indicate if soil contaminants are in groundwater (Figure 10.1.2). Groundwater was sampled in accordance with the *Final Zone C Work Plan* (E/A&H November 1995) and Section 3 of this report. The groundwater sample was analyzed for SVOCs, pesticide/PBCs, and metals at DQO Level III.

SVOCs, pesticides, and PCBs were not detected indicating that the concentrations in soil are protective of groundwater. Groundwater analytical results for inorganics are in Table 10.9.4. Appendix D is complete report of the analytical data for Zone C and Appendix H contains detection only summary tables.

Table 10.9.4
Inorganics Analytical Results for Groundwater
AOC 700 — Monitoring Wells

Compound	Depth Interval	Frequency of Detection	Range of Detection (μg/L)	Mean (μg/L)	Reference Conc. (μg/L)	Number of Samples Exceeding Reference
Aluminum	Shallow	1/1	901.0	NA	410	1
Arsenic	Shallow	1/1	11.5	NA	6.07	1
Barium	Shallow	1/1	21.7	NA	16.7	1
Beryllium	Shallow	1/1	0.53	NA	0.33	1
Calcium	Shallow	1/1	163,000	NA	NA	NA
Chromium	Shallow	1/1	3.3	NA	1.99	1
Copper	Shallow	1/1	3.6	NA	1.90	1
Iron	Shallow	1/1	3390	NA	NA	NA
Magnesium	Shallow	1/1	279,000	NA	NA	NA
Manganese	Shallow	1/1	722.0	NA	608.0	1
Mercury	Shallow	1/1	0.11	NA	ND	1
Nickel	Shallow	1/1	1.8	NA	3.59	1
Potassium	Shallow	1/1	143,000.0	NA	NA	NA
Sodium	Shallow	1/1	2,520,000.0	NA	NA	NA
Vanadium	Shallow	1/1	8.7	NA	1.96	1

Inorganic Analytes in Groundwater

Fifteen inorganics were detected in monitoring well 044GW008. Table 10.9.3 lists the inorganic analytical results. All of the detected inorganics exceeded their respective reference concentrations.

10.9.4 Fate and Transport Assessment

AOC 700 is the golf course maintenance shop (Building 1646), located in the northwest quadrant of the intersection of Avenue D and Hunt Street. SWMU 44 Former Coal Storage Area is located immediately west of the AOC. Currently, this AOC is an open area surrounding Building 1646. For the purposes of the fate and transport assessment, AOC 700 was assessed alone although groundwater data from adjacent SWMU 44 was used to confirm or refute the screening outcome. Migration pathways investigated for AOC 700 include soil to groundwater and surface soil to air. Environmental media sampled as part of the AOC 700 RFI included surface soil and subsurface soil.

10.9.4.1 Soil-to-Groundwater Cross-Media Transport

Table 10.9.5 compares constituents found in both surface soil and subsurface soil with concentrations to groundwater protection risk-based SSLs and background reference concentrations. Five constituents (chromium, cobalt, copper, thallium and dieldrin) were detected in AOC 700 soil at concentrations above groundwater protection SSLs or background reference concentrations. Chromium was detected consistently above its SSL at both sampling intervals, with maximum concentrations reported at location 700-005. Valence specific analyses determined that most if not all chromium exists in its less soluble trivalent state. As a result, the potential for leaching is considered minimal.

Cobalt was detected in one sample above its reference concentration (700-002-02), and the site mean was less than the reference concentration. Copper was detected in samples 700-002-02 and 700-003-02 above its reference concentration. Thallium was detected in a single sample (700-003-01) but the duplicate at this location was non detect. Thallium was not detected in any subsurface sample.

Table 10.9.5
Chemicals Detected in Surface Soil and Subsurface Soil
Comparison to Groundwater Protection SSLs and Background UTLs
NAVBASE-Charleston, Zone C, AOC 700
Charleston, South Carolina

Parameter	Surface Soil Maximum Conc.	Subsurface Soil Maximum Conc.	Ground Water Protection SSL or UTL *	Soil Units	Soil Conc. Exceeds SSL or UTL
Aluminum	3450	3490	23700	MG/KG	NO
Anthracene	48	58	1200000	UG/KG	NO
Antimony	ND	4.7	5	MG/KG	NO
Arsenic	14.3	17.4	29	MG/KG	NO
Benzo(a)anthracene	140	72	2000	UG/KG	NO
Benzo(a)pyrene	230	64	8000	UG/KG	NO
Benzo(b)fluoranthene	345	94	5000	UG/KG	NO
Benzo(k)fluoranthene	280	95	49000	UG/KG	NO
Chrysene	340	120	160000	UG/KG	NO
Dibenz(a,h)anthracene	68.5	ND	2000	UG/KG	NO
Indeno(1,2,3-cd)pyrene	145	45	14000	UG/KG	NO
Benzo(g,h,i)perylene	160	ND	46000	UG/KG	NO
Benzoic acid	78	120	40000	UG/KG	NO
* Beryllium	0.285	0.73	63	MG/KG	NO
Cadmium	1.11	0.56	8	MG/KG	NO
alpha-Chlordane	3.15	ND	10000	UG/KG	NO
gamma-Chlordane	6.5	ND	10000	UG/KG	NO
* Chromium	224	280	38	MG/KG	YES
Chromium (hexavalent)	ND	ND	38	MG/KG	NO
Cobalt	2.5	12.8	7.1	MG/KG	YES
Copper	31.1	92.4	42.2	MG/KG	YES
p-Cresol	42	ND	6000	UG/KG	NO
Cyanide	0.24	0.39	1	MG/KG	NO
4,4'-DDE	61	25	54000	UG/KG	NO
4,4'-DDD	9.7	13	16000	UG/KG	NO
4,4'-DDT	77	34	32000	UG/KG	NO
Dibenzofuran	230	130	12000	UG/KG	NO
Dieldrin	5.9	9.2	4	UG/KG	YES
Dioxin (TCDD TEQ)	3.032	NA	4000	PG/G	NO
bis(2-Ethylhexylphthalate)	81	54	3600000	UG/KG	NO
Fluoranthene	480	180	430000	UG/KG	NO
Heptachlor	1.2	ND	23000	UG/KG	NO
Heptachlor epoxide	1.95	ND	700	UG/KG	NO
Iron	4810	8740		MG/KG	
Lead	55.3	327	330	MG/KG	NO
Manganese	71.4	56.5	106	MG/KG	NO
2-Methylnaphthalene	960	210	51000	UG/KG	NO
Naphthalene	480	160	8400	UG/KG	NO
Nickel	6.8	35.7	130	MG/KG	NO
Phenanthrene	550	140	10000000	UG/KG	NO
Pyrene	505	190	420000	UG/KG	NO
Selenium	0.93	0.55	5	MG/KG	NO
* Thallium	1.13	ND	0.7	MG/KG	YES
Vanadium	9.9	9.7	600	MG/KG	NO
Zinc	309	583	1200	MG/KG	NO

Table 10.9.5
Chemicals Detected in Surface Soil and Subsurface Soil
Comparison to Groundwater Protection SSLs and Background UTLs
NAVBASE-Charleston, Zone C, AOC 700
Charleston, South Carolina

Parameter	Surface Soil Maximum Conc.	Subsurface Soil Maximum Conc.	Ground Water Protection SSL or UTL *	Soil Units	Soil Conc. Exceeds SSL or UTL

Notes:
* - See Table 6-2
NA - Not available
ND - Not detected
SSL - Groundwater protection soil screening level
UTL - Grid-based background upper tolerance limit
MG/KG - Milligram per kilogram
UG/KG - Micrograms per kilogram
j Based on proposed action level for soil and treatment technique action level for water.
k Fluoranthene used as surrogate
l gamma-BHC used as surrogate

Dieldrin was found above its SSL at a single boring location (700-005) at both depth intervals. These results indicate a potential for isolated impacts to the shallow aquifer. Due to the isolated potential threat to the shallow water bearing zone, a decision was made to conduct a limited groundwater investigation. Rather than install site-specific monitoring wells, the NAVBASE project team decided to evaluate results from monitoring well 044008 which is located approximately 50 feet downgradient of AOC 700. Results from this well showed that the levels of each parameter of potential concern (with respect to soil to groundwater migration) were below their respective RBCs and/or reference concentrations. Neither thallium nor dieldrin was detected in 044008. Therefore, there are no indications that the identified groundwater protection issues are reflected in actual shallow aquifer quality at AOC 700.

10.9.4.2 Soil-to-Air Cross-Media Transport

No volatile organic compounds were detected in surface soil samples collected at AOC 700. As a result, no soil-to-air migration pathway screening was performed.

10.9.5 Human Health Risk Assessment for AOC 700

10.9.5.1 Site Background and Investigative Approach

This area was investigated to assess soil possibly affected by past site activities. It consists of AOC 700, which is the golf course maintenance building adjacent to SWMU 44. Currently, the site is an open area surrounding Building 1646 in the northwest quadrant of the Avenue D/Hunt Street intersection.

Five soil samples collected from the upper interval of AOC 700 were used to develop the list of methods in Table 10.9.6.

Table 10.9.6
Methods Run at AOC 700
Surface Soil

Site	Location	Metal	SVOA	VOA	CN	Hex-Cr	Diox	Herb	Pest	Oppe
700	B001	Y	Y	Y	Y				Y	
700	B002	Y	Y	Y	Y				Y	
700	B003	D	D	D	Y	Y	Y	Y	D	Y
700	B004	Y	Y	Y	Y				Y	
700	B005	Y	Y	Y	Y				Y	

Methods:
Metal - TAL (Target Analyte List) Metals plus tin; Methods 6000/7000 Series
SVOA - Semi-volatile Organics; Method 8270
VOA - Volatile Organics; Method 8240
CN - Cyanide (Soil: Method 9010)
Pest - Pesticides/PCBs; Method 8080
Hex-Cr - Hexavalent Chromium; Method 7195
Dioxin - Dioxin; Method 8290
Oppe - Organophosphate Pesticides: Method 8140
Herb - Chlorinated Herbicides: Method 8150

Key:
Y - Analyzed for standard list
D - Duplicate analysis

10.9.5.2 COPC Identification

Soil

Screening comparisons described in Section 7 are shown in Table 10.9.7. Arsenic, beryllium, chromium, thallium and BEQs were tentatively identified as surface soil COPCs. Chromium was identified as a COPC based on comparison of the maximum reported surface soil concentration (224 mg/kg) to the residential RBC for hexavalent chromium (39 mg/kg). Hexavalent chromium analyses performed on one sample from AOC 700 were non detect indicating that chromium exists predominantly in its trivalent form. A comparison of surface soil results to the trivalent chromium RBC (7,800 mg/kg) showed that existing surface soil levels should not pose a significant hazard. As a result, chromium was not carried forward to formal assessment.

Beryllium was detected in each surface soil sample ranging from 0.14 to 0.285 mg/kg with a mean of 0.229 mg/kg. Due to the number of non-detect reported for background locations, no reference concentration was computed. A review of background location surface soil data found concentrations ranging from non-detect to 0.26 mg/kg with subsurface levels reaching nearly 1 mg/kg. Based on these findings, it was concluded that onsite beryllium results were comparable to those at background locations and did not reflect impacts associated with past site uses. As a result, beryllium was not retained as a COPC for AOC 700.

Arsenic and thallium were each carried forward to formal assessment. Each warrants closer evaluation, however, relative to its importance. Arsenic was detected in a single sample (700-005-01 (14.3 mg/kg) above its reference concentration (14.2 mg/kg). The result is essentially identical to the background level in consideration of analytical variability. Thallium was detected exclusively in sample 700-003-01 (2 mg/kg) but was not detected in the duplicate sample at this location. As a result, there is some doubt as to whether the hit is indicative of soil quality at this location.

Table 10.9.7
AOC 700 - Golf Course Maintenance Building
Surface Soil

Parameter	Units	Frequency of Detection	Range of Non detected Upper Bounds	Range of Detected Concentrations	Average Detected Conc.	Screening Conc.(s)	Num. Over Screen	Ref. Conc.	Num. Over Ref.
Aluminum	MG/KG	5 / 5		2650 - 3450	3100	7800		9990	
Anthracene	UG/KG	2 / 5	350 - 380	43 - 48	45.5	2300000			
Arsenic	MG/KG	5 / 5		3 - 14.3	7.71	0.43	5	14.2	
* Benzo(a)pyrene Equivalents	UG/KG	5 / 5		69.63 - 364.53	160.5	88	4		
Benzo(a)anthracene	UG/KG	5 / 5		48 - 140	109.6				
Benzo(a)pyrene	UG/KG	5 / 5		51 - 230	108.2				
Benzo(b)fluoranthene	UG/KG	5 / 5		88 - 345	200.6				
Benzo(k)fluoranthene	UG/KG	5 / 5		56 - 280	139.4				
Chrysene	UG/KG	5 / 5		75 - 340	208				
Dibenz(a,h)anthracene	UG/KG	1 / 5	360 - 380	68.5 - 68.5	68.5				
Indeno(1,2,3-cd)pyrene	UG/KG	4 / 5	360 - 360	44 - 145	75				
Benzo(g,h,i)perylene	UG/KG	4 / 5	370 - 370	47 - 160	86.5	310000			
Benzoic acid	UG/KG	2 / 5	1800 - 1800	61 - 78	69.5	31000000			
* Beryllium	MG/KG	5 / 5		0.14 - 0.285	0.229	0.15	4	ND	5
Cadmium	MG/KG	1 / 5	0.04 - 0.07	0.14 - 1.11	0.526	3.9		0.65	
alpha-Chlordane	UG/KG	2 / 5	1.4 - 1.5	2.2 - 3.15	2.66	490			
gamma-Chlordane	UG/KG	2 / 5	1.5 - 6	3.4 - 6.5	4.95	490			
* Chromium	MG/KG	5 / 5		21.35 - 224	81.2	39	4	26.4	4
Chromium (hexavalent)	MG/KG	0 / 1	0.266 - 0.266			39		ND	
Cobalt	MG/KG	4 / 5		1 - 2.5	1.81	470		3.22	
Copper	MG/KG	2 / 5		4.7 - 31.1	16.83	290		42.2	
p-Cresol	UG/KG	1 / 5	350 - 380	42 - 42	42	39000			
Cyanide	MG/KG	4 5	0.11 - 0.11	0.12 - 0.24	0.183				
4,4'-DDE	UG/KG	5 / 5		2.9 - 61	27.98	1900			
4,4'-DDD	UG/KG	1 / 5	2.7 - 2.9	9.7 - 9.7	9.7	2700			
4,4'-DDT	UG/KG	4 / 5	2.7 - 2.7	18 - 77	35.25	1900			
Dibenzofuran	UG/KG	4 / 5	350 - 350	87 - 230	144.75	31000			
Dieldrin	UG/KG	1 / 5	2.7 - 2.8	5.9 - 5.9	5.9	40			
Dioxin (TCDD TEQ)	PG/G	1 / 1		3.032 - 3.032	3.032	1000			
bis(2-Ethylhexylphthalate)	UG/KG	3 / 5	360 - 380	37 - 81	57	46000			
Fluoranthene	UG/KG	5 / 5		82 - 480	210.4	310000			
Heptachlor	UG/KG	1 / 5	1.4 - 1.7	1.2 - 1.2	1.2	140			
Heptachlor epoxide	UG/KG	1 / 5	1.4 - 1.7	1.95 - 1.95	1.95	70			
Iron	MG/KG	5 / 5		2730 - 4810	3443				
Lead	MG/KG	5 / 5		27.3 - 55.3	41.5	400 j		330	
Manganese	MG/KG	5 / 5		25.8 - 71.4	45.6	180		92.5	

Table 10.9.7
AOC 700 - Golf Course Maintenance Building
Surface Soil

	Parameter	Units	Frequency of Detection	Range of Non detected Upper Bounds	Range of Detected Concentrations	Average Detected Conc.	Screening Conc.(s)	Num. Over Screen	Ref. Conc.	Num. Over Ref.
	2-Methylnaphthalene	UG/KG	5 / 5		102 - 960	388.4	310000 (I)			
	Naphthalene	UG/KG	5 / 5		71 - 480	242.2	310000			
	Nickel	MG/KG	2 / 5	2.4 - 4	6.75 - 6.8	6.8	85			
	Phenanthrene	UG/KG	5 / 5		102.5 - 550	338.5	310000 k			
	Pyrene	UG/KG	5 / 5		76 - 505	264.2	230000			
	Selenium	MG/KG	1 / 5	0.33 - 0.53	0.93 - 0.93	0.93	39			
*	Thallium	MG/KG	1 / 5	0.37 - 0.53	1.13 - 1.13	1.13	0.63	1	ND	5
	Vanadium	MG/KG	5 / 5		4.1 - 9.9	6.2	55		23.4	
	Zinc	MG/KG	5 / 5		89.5 - 309	168.6	2300		159	

Notes:
* Retained as a chemical of potential concern
s USEPA Region III Residential Risk -Based Screening Value, January-June 1996
e Acenaphthene used as surrogate
f Fluoranthene used as surrogate
g Endosulfan used as surrogate
h Endrin used as surrogate
I Naphthalene used as surrogate
j Based on proposed action level for soil and treatment technique action level for water.
k Fluoranthene used as surrogate
l gamma-BHC used as surrogate

10.9.5.3 Exposure Assessment

Exposure Setting

AOC 700 comprises approximately 6,000 square feet of open area near Building 1646, which is located immediately east of SWMU 44. Current exposure would be limited to infrequent NAVBASE maintenance activities. The future use of the AOC is unknown, although the general vicinity is slated to be open space and/or community support area in the base reuse plan.

Potentially Exposed Populations

Potentially exposed populations are current and future site workers. Additional potentially exposed populations are future site residents. Future site resident and worker exposure scenarios were addressed in this risk assessment. The hypothetical future site worker scenario assumed continuous exposure to surface soil conditions. Current site workers' exposure would be less than that assumed for the hypothetical future site worker scenario because of their limited soil contact. Therefore, future worker assessment is considered to be protective of current site users.

Exposure Pathways

Exposure pathways for the site workers are dermal contact and incidental ingestion of surface soil. The exposure pathways for future residential land use are the same as those for the future site worker. In addition, the hypothetical future site worker scenario assumed continuous exposure to surface soil conditions. Uniform exposure was assumed for all sample locations. Table 10.9.8 presents the justification of exposure pathways assessed in this HHRA.

Exposure Point Concentrations

As discussed in Section 7, UCLs were calculated for datasets consisting of at least 10 samples. Only five surface soil samples were collected, thus no UCLs were computed for AOC 700. Table 10.9.9 presents the EPCs for AOC 700. FI/FC was used to adjust exposure estimates for

Table 10.9.8
Exposure Pathways Summary — AOC 700
NAVBASE — Zone C
Charleston, South Carolina

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Current Land Uses			
Current Site Users/Maintenance	Air, Inhalation of gaseous contaminants emanating from soil	No	No significant VOC concentrations were reported in surface soils, and portions of the site area are paved/covered by buildings.
	Air, Inhalation of chemicals entrained in fugitive dust	No	Portions of the site area are paved/covered by buildings, which limits fugitive dust generation.
	Shallow groundwater, Ingestion of contaminants during potable or general use	No	Shallow groundwater is not currently used as a source of potable or non-residential water at AOC 700.
	Shallow groundwater, Inhalation of volatilized shallow groundwater contaminants	No	Shallow groundwater is not currently used as a source of potable or non-residential water at AOC 700.
	Soil, Incidental ingestion	No (Qualified)	Future land use assessment is considered to be protective of current receptors.
	Soil, Dermal contact	No (Qualified)	Future land use assessment is considered to be protective of current receptors.
Future Land Uses			
Future Site Residents (Child and Adult) and Future Site Worker	Air, Inhalation of gaseous contaminants emanating from soil	No	No significant VOC concentrations were reported in surface soils, and portions of the site area are paved/covered by buildings.
	Air, Inhalation of chemicals entrained in fugitive dust	No	Portions of the site area are paved/covered by buildings, which limits fugitive dust generation.
	Shallow groundwater, Ingestion of contaminants during potable or general use	No	No groundwater sampling was performed in conjunction with the 700 investigation.
	Shallow groundwater, Inhalation of volatilized contaminants during domestic use	No	No groundwater sampling was performed in conjunction with the 700 investigation.

Table 10.9.8
Exposure Pathways Summary — AOC 700
NAVBASE — Zone C
Charleston, South Carolina

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Future Land Uses			
Future Site Residents (Child and Adult) and Future Site Worker	Soil, Incidental ingestion	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Soil, Dermal contact	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Wild game or domestic animals, Ingestion of tissue impacted by media contamination	No	Hunting/taking of game and/or raising livestock is prohibited within the Charleston, South Carolina City Limits.
	Fruits and vegetables, Ingestion of plant tissues grown in media	No	The potential for significant exposure via this pathway is low relative to that of other exposure pathways assessed.

Table 10.9.9
Statistical Analysis of COPCs
Surface Soils at AOC 700
Naval Base Charleston Zone H
Charleston, South Carolina

COPC	n	Natural Log Transforme mean	SD	H-stat	UCL (mg/kg)	MAX (mg/kg)	EPC (mg/kg)		TEF	Adjusted EPC (mg/kg)
Benzo(a)pyrene Equivalents	5	NA	NA	NA	NA	0.365	0.365	MAX Used	1	0.365
Arsenic	5	NA	NA	NA	NA	14.3	14.3	MAX Used	NA	14.3
Thallium	5	NA	NA	NA	NA	1.13	1.1	MAX Used Hot Spot	NA	1.1

NOTES:

mean arithmetic mean of the logtransformed data
n number of samples analyzed
SD standard deviation for a sample of data
H-stat "H" statistic from Gilbert 1987, cuboidal interpolation was used to determine the value in accordance with USEPA Supplemental Guidance to RAGS, Calculating the Concentration Term
NA not applicable
TEF toxic equivalency factor
EPC exposure point concentration
UCL 95 percentile upper confidence level mean
MAX maximum reported concentration
HOT SPOT the mean and/or maximum concentration was used to estimate exposure for impacts limited to a small area of the site.

thallium at 0.3 because the maximum area of impact was estimated to be less than 5,000 square feet. The single thallium detection was bounded by non detects.

Quantification of Exposure

Soil

CDIs for ingestion and dermal contact with surface soil are shown in Tables 10.9.10 and 10.9.11, respectively.

10.9.5.4 Toxicity Assessment

Toxicity assessment terms and methods are discussed in Section 7 of this report. Each COPC identified at AOC 700 is discussed briefly below. Table 10.9.12 presents the toxicological information used to quantify risk and hazard associated with soil COPCs.

Polyaromatic hydrocarbons or BaP equivalents include the following list of COPCs:

Benzo(a)anthracene	TEF	0.1
Benzo(b)fluoranthene	TEF	0.1
Dibenz(a,h)anthracene	TEF	1.0
Benzo(k)fluoranthene	TEF	0.01
Benzo(a)pyrene	TEF	1.0
Indeno(1,2,3-cd)pyrene	TEF	0.1
Chrysene	TEF	0.001

Some PAHs are toxic to the liver, kidney, and blood. However, the toxic effects of the PAHs above have not been well established. There are no RfDs for the PAHs above due to a lack of data. All PAHs listed above are classified by USEPA as B2 carcinogens, and their carcinogenicity is addressed relative to that of BaP, having an oral SF 7.3 $(mg/kg\text{-}day)^{-1}$. TEFs, also set by

Table 10.9.10
Chronic Daily Intakes (CDI)
Incidental Ingestion of Surface Soil (0-1')
AOC 700 Zone C
Naval Base Charleston
Charleston, SC

Chemical	TEF	Fraction Ingested fro Contaminate Source	Exposure Point Concentration (mg/kg)	Potential Future Resident adult H-CDI (mg/kg-day)	Potential Future Resident child H-CDI (mg/kg-day)	Potential Futur Resident lwa C-CDI (mg/kg-day)	Potential Curren Worker adult H-CDI (mg/kg-day)	Potential Current Worker adult C-CDI (mg/kg-day)
Benzo(a)pyrene Equival	1	1	0.365	4.99E-07	4.66E-06	5.71E-07	1.78E-07	6.37E-08
Arsenic	NA	1	14.3	1.96E-05	1.83E-04	2.24E-05	7.00E-06	2.50E-06
Thallium	NA	0.3	1.1	4.64E-07	4.33E-06	5.31E-07	1.66E-07	5.92E-08

NOTES:

TEF	toxic equivalency factor relative to Benzo(a)pyrene
lwa	lifetime weighted average, used to calculate carcinogenic CDI, RAGS Parts A and B
CDI	Chronic Daily Intake in mg/kg-day
H-CDI	CDI for hazard quotient
C-CDI	CDI for excess cancer risk
*	Reflects the estimated fraction of the site impacted by the corresponding COPC.

Table 10.9.11
Chronic Daily Intakes (CDI)
Dermal Contact with Surface Soil (0-1')
AOC 700 Zone C
Naval Base Charleston
Charleston, SC

Chemical	TEF	Adjusted Exposure Point Concentratio (mg/kg)	Fraction Contacted fr Contaminate Source *	Dermal Absorption Factor (unitless)	Potential Future Resident adult H-CDI (mg/kg-day)	Potential Future Resident child H-CDI (mg/kg-day)	Potential Futur Resident lwa C-CDI (mg/kg-day)	Potential Curren Worker adult H-CDI (mg/kg-day)	Potential Curren Worker adult C-CDI (mg/kg-day)
Benzo(a)pyrene Equiv	1	0.3645	1	0.01	2.05E-07	6.76E-07	1.28E-07	1.46E-07	5.22E-08
Arsenic	NA	14.3	1	0.001	8.03E-07	2.65E-06	5.03E-07	5.74E-07	2.05E-07
Thallium	NA	1.13	0.3	0.001	1.90E-08	6.28E-08	1.19E-08	1.36E-08	4.86E-09

NOTES:

TEF Toxic Equivalency Factor relative to Benzo(a)pyrene
CDI Chronic Daily Intake in mg/kg-day
H-CDI CDI for hazard quotient
C-CDI CDI for excess cancer risk
- The dermal absorption factor was applied to the exposure point concentration to reflect the different trans-dermal migration of inorganic versus organic chemicals
* Reflects the estimated fraction of the site impacted by the corresponding COPC.

Table 10.9.12
Toxicological Database Information
for Chemicals of Potential Concern
AOC 700
NAVBASE Charleston, Zone C

Non-Carcinogenic Toxicity Data

Chemical	Oral Reference Dose (mg/kg/day)		Confidence Level	Critical Effect	Uncertainty Factor Oral	Inhalation Reference Dose (mg/kg/day)	Confidence Level	Critical Effect	Uncertainty Factor Inhalation
Arsenic	0.0003	a	M	hyperpigmentation	3	ND			ND
Benzo(a)pyrene Equivalents	ND				ND	ND			ND
Thallium	8E-05	a		increased SGOT (liver) increased serum LDH	3000	ND			ND

NOTES:

a Integrated Risk Information System (IRIS)
b Health Effects Assessment Summary Tables (HEAST)
c HEAST alternative method
d USEPA Region III Screening Tables
e EPA Environmental Criteria and Assessment Office - Cincinnati (provisional)
f Withdrawn from IRIS or HEAST
NA Not applicable or not available
ND Not determined due to lack of information

Table 10.9.12
Toxicological Database Information
for Chemicals of Potential Concern
AOC 700
NAVBASE Charleston, Zone C

Carcinogenic Toxicity Data

Chemical	Oral Slope Factor [(mg/kg/day)]-1		Inhalation Slope Factor [(mg/kg/day)]-1		Weight of Evidence	Tumor Type		
Arsenic	1.5	a	15.1	a	A	various	m	
Benzo(a)pyrene Equivalents	7.3	a			B2	mutagen		NEW
Thallium	ND		ND		D			NEW

USEPA, are multipliers that are applied to the detected concentrations, which are subsequently used to calculate excess cancer risk. These multipliers are discussed further in the exposure and toxicity assessment sections. Most carcinogenic PAHs have been classified as such due to animal studies using large doses of purified PAHs. There is some doubt as to the validity of these listings, and the SFs listed in USEPA's RBC table are provisional. However, these PAHs are carcinogens when the exposure involves a mixture of other carcinogenic substances (e.g., coal tar, soot, cigarette smoke, etc.). As listed in IRIS (search data June 28, 1995), the basis for the BaP B2 classification is a lack of human data specifically linking BaP to a carcinogenic effect. However, multiple animal studies in many species demonstrating BaP to be carcinogenic by numerous routes.

BaP has produced positive results in numerous genotoxicity assays. At the June 1992 CRAVE Work Group meeting, a revised risk estimate for BaP was verified. This section provides information on three aspects of the carcinogenic risk assessment for the agent in question: the USEPA classification and quantitative estimates of exposure. The classification reflects a weight-of-evidence judgment of the likelihood that the agent is a human carcinogen. The quantitative risk estimates are presented in application of a low-dose extrapolation procedure and presented as the risk per mg/kg-day. The unit risk is the quantitative estimate in terms of either risk per μg/L drinking water or risk per $\mu g/m^3$ air breathed. The third form in which risk is presented is drinking water or air concentration providing cancer risks of one in 10,000 or one in 1,000,000. The Carcinogenicity Background Document provides details on the carcinogenicity values found in IRIS. Users are referred to the oral reference dose and reference concentration sections for information on long-term toxic effects other than carcinogenicity.

As listed in IRIS (search date June 28, 1995), the basis for the dibenz(a,h)anthracene and benzo(b)fluoranthene B2 classification is no human data but sufficient data from animal bioassays. Benzo(b)fluoranthene produced tumors in mice after lung implantation, intraperitoneal or subcutaneous injection, and skin painting. As listed in IRIS (search date June 28, 1995), the basis for the benzo(a)anthracene B2 classification is no human data but sufficient data from animal bioassays. Benzo(a)anthracene produced tumors in mice exposed by gavage; intraperitoneal, subcutaneous, or intramuscular injection; and topical application. Benzo(a)anthracene produced mutations in bacteria and in mammalian cells, and transformed mammalian cells in culture. As listed in IRIS (search date June 28, 1995) the basis for the benzo(k)fluoranthene B2 classification is no human data but sufficient data from animal bioassays. Benzo(k)fluoranthene produced tumors after lung implantation in mice and when administered with a promoting agent in skin-painting studies. Equivocal results have been found in a lung adenoma assay in mice. Benzo(k)fluoranthene is mutagenic in bacteria (Klaassen, et al., 1986).

Other PAHs — those not classified by USEPA as carcinogens — are toxic to the liver, kidney and blood. This group of PAHs includes compounds such as pyrene, acenaphthene, acenaphthylene, benzo(g,h,i)perylene, and phenanthrene. USEPA determined RfDs for only two of these compounds: pyrene's RfDo of 0.03 mg/kg-day is also used as a surrogate RfDo for phenanthrene. The RfDo for acenaphthene was 0.06 mg/kg-day.

Arsenic exposure via the ingestion route causes darkening and hardening of the skin in chronically exposed humans. Inhalation exposure to arsenic causes neurological deficits, anemia, and cardiovascular effects (Klaassen, et al., 1986). USEPA set 0.3 μg/kg/day as the RfD for arsenic based on a NOAEL of 0.8 μg/kg-day in a human exposure study. Arsenic's effects on the nervous and cardiovascular systems are primarily associated with acute exposure to higher levels. Exposure to arsenic-containing materials has been shown to cause cancer in humans. Inhalation of these materials can lead to increased lung cancer risk, and ingestion of these materials is associated with increased skin cancer rates. Arsenic has been classified as a group A carcinogen by USEPA, which set the 1.5 (mg/kg-day)$^{-1}$ SF for arsenic. As listed in IRIS (search date September 1, 1995), the basis for the classification is sufficient evidence from human data. An increased lung cancer mortality was observed in multiple human populations exposed primarily through inhalation. Also, increased mortality from multiple internal organ cancers (liver, kidney, lung, and bladder) and an increased incidence of skin cancer were observed in populations consuming drinking water high in inorganic arsenic. Human milk contains about 3 μg/L arsenic (Klaassen, et al., 1986). The RBC for arsenic in tap water is 0.038 μg/L. As listed in IRIS (search date September 1, 1995), the critical effect of this chemical is hyperpigmentation, keratosis, and possible vascular complications. The uncertainty factor was determined to be 3 and the modifying factor was determined to be 1.

Thallium is readily absorbed through the gut and skin. Primary effects are stomach and bowel disturbances, kidney and liver damage, and neurological disturbances. Thallium was used in the past as a rodenticide and ant killer, and its use for these purposes is now prohibited. This element remains in the body for a relatively long time, and could accumulate if the chronic dose is large (Klaassen, et al, 1986) (Dreisbach, et al, 1987). USEPA's RfDo for thallium is 0.00008 mg/kg-day

10.9.5.5 Risk Characterization

Surface Soil Pathways

Exposure to surface soil onsite was evaluated under both residential and industrial (site worker) scenarios. For these scenarios, the incidental ingestion and dermal contact exposure pathways were evaluated. For noncarcinogenic contaminants evaluated for future site residents, hazard was computed separately to address child and adult exposure. Tables 10.9.13 and 10.9.14 present the estimated carcinogenic risks and/or HQs associated with the incidental ingestion of and dermal contact with site surface soil, respectively.

Hypothetical Site Residents

The ingestion ILCR (based on adult and child lifetime weighted average) for AOC 700 surface soil is 4E-5. The dermal pathway ILCR is 6E-6. Arsenic was the primary contributor with BEQs secondary.

Table 10.9.14
Hazard Quotients and Incremental Lifetime Cancer Risks
Dermal Contact With Surface Soil
AOC 700 Zone C
Naval Base Charleston
Charleston, SC

Chemical	Dermal Adjustment	Oral RfD Used (mg/kg-day	Oral SF Used (mg/kg-day)-1	Potential Future Resident adult Hazard Quotient	Potential Future Resident child Hazard Quotient	Potential Futu Resident lwa ILCR	Potential Curren Worker adult Hazard Quotient	Potential Current Worker adult ILCR
Benzo(a)pyrene Equiv	0.5	NA	14.6	ND	ND	1.9E-06	ND	7.6E-07
Arsenic	0.2	6E-05	7.5	0.01	0.04	3.8E-06	0.01	1.5E-06
Thallium	0.2	1.6E-05	NA	0.001	0.00	ND	0.001	ND
SUM Hazard Index/ILCR				0.01	0.05	6E-06	0.01	2E-06

NOTES:

NA Not available
ND Not Determined due to lack of available information
lwa lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime excess Cancer Risk
\- Dermal to absorbed dose adjustment factor is applied to adjust for Oral SF and RfD (i.e., the oral RfD is based on oral absorption efficiency which should not be applied to dermal exposure and dermal CDI)

Table 10.9.13
Hazard Quotients and Incremental Lifetime Cancer Risks
Incidental Surface Soil Ingestion
AOC 700 Zone C
Naval Base Charleston
Charleston, SC

Chemical	Oral RfD Used (mg/kg-day)	Oral SF Used (mg/kg-day)-1	Potential Future Resident adult Hazard Quotient	Potential Future Resident child Hazard Quotient	Potential Futur Resident lwa ILCR	Potential Curren Worker adult Hazard Quotient	Potential Current Worker adult ILCR
Benzo(a)pyrene Equivale	NA	7.3	ND	ND	4.2E-06	ND	4.6E-07
Arsenic	0.0003	1.5	0.1	0.6	3.4E-05	0.02	3.7E-06
Thallium	8E-05	NA	0.01	0.1	ND	0.002	ND
SUM Hazard Index/ILCR			0.1	0.7	4E-05	0.03	4E-06

NOTES:

NA Not available
ND Not Determined due to lack of available information
lwa lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime excess Cancer Risk
- the one hit equation for high carcinogenic risk was used to calculate the resident lwa and worker ILCR

The ingestion HIs for the adult and child residents were 0.1 and 0.7, respectively. The dermal contact HIs for the adult and child residents were 0.01 and 0.06, respectively. Arsenic and thallium were the primary contributors to the HI for both the ingestion and dermal contact exposure pathways.

Hypothetical Site Workers

Site worker ILCR was estimated to be 4E-6 and 2E-6 for the ingestion and dermal contact pathways, respectively. Arsenic and BEQ were the primary contributors for each pathway. Site worker ingestion and dermal contact HIs were 0.03 and 0.01, respectively. Arsenic was the primary contributor to the HI for both the ingestion and dermal contact exposure pathways.

COCs Identified

COCs are identified based on cumulative (all pathways) risk and hazard projected for this site. USEPA has established a generally acceptable risk range of 1E-4 to 1E-6, and a hazard index threshold of 1.0 (unity). In this HHRA, a COC was considered to be any chemical contributing to a cumulative risk level of 1E-6 or whose hazard quotient exceeds 0.1. For carcinogens, this approach is relatively conservative, because a cumulative risk level of 1E-4 (and individual ILCR of 1E-6) is recommended by USEPA Region IV as the trigger for establishing COCs. The COC selection method presented was used to provide a more comprehensive evaluation of chemicals contributing to carcinogenic risk or noncarcinogenic hazard during the RGO development process. Table 10.9.15 summarizes COCs identified as well as risk and hazard for each exposure pathway and scenario.

Surface Soil

Hypothetical Site Residents (Future Land Use)

Arsenic and BEQ were identified as COCs for this scenario based on the sum ILCR.

Table 10.9.15
Summary of Risk and Hazard-based COCs for AOC 700
NAVBASE - Charleston Zone C
Charleston, South Carolina

Medium	Exposure Pathway		Potential Future Resident Adult Hazard Quotient	Potential Future Resident Child Hazard Quotient	Potential Future Resident Iwa ILCR	Site Worker Hazard Quotient	Site Worker ILCR	Identification of COCs	
Surface Soil	Incidental Ingestion	Benzo(a)pyrene Equivale	ND	ND	4.2E-06	ND	4.6E-07	2	4
		Arsenic	0.1	0.6	3.4E-05	0.02	3.7E-06	2	4
		Thallium	0.01	0.1	ND	0.002	ND		
	Dermal Contact	Benzo(a)pyrene Equivale	ND	ND	1.9E-06	ND	7.6E-07	2	4
		Arsenic	0.01	0.04	3.8E-06	0.01	1.5E-06	2	4
		Thallium	0.001	0.00	ND	0.001	ND		
Surface Soil Pathway Sum			0.09	0.7	4E-05	0.036	7E-06		
Sum of All Pathways			0.1	0.7	4E-05	0.04	7E-06		

Notes:
ND indicates not determined due to the lack of available risk information.
ILCR indicates incremental excess lifetime cancer risk
HI indicates hazard index
1- Chemical is a COC by virtue of projected child residence non-carcinogenic hazard.
2- Chemical is a COC by virtue of projected future resident lifetime ILCR.
3- Chemical is a COC by virtue of projected site worker non-carcinogenic hazard.
4- Chemical is a COC by virtue of projected site worker ILCR.

Hypothetical Site Workers (Future Land Use)

Arsenic and BEQs were identified as the sole COC for this scenario based on the sum ILCR or hazard index.

10.9.5.6 Risk Uncertainty

Characterization of Exposure Setting and Identification of Exposure Pathways

The potential for high bias is introduced through the exposure setting and pathway selection due to the highly conservative assumptions (i.e., future residential use) recommended by USEPA Region IV when assessing potential future and current exposure. The exposure assumptions made in the site worker scenario are highly protective and would tend to overestimate exposure. Under current site use conditions, workers are infrequently exposed to surface soil when performing maintenance activities or walking across the site. Most of the site is either vegetated or paved, limiting fugitive dust generation and exposure to soil.

Residential use of the site would not be expected based on current reuse plans, which have scheduled AOC 700 to be used as open space and community support area. If this area were used as a residential site, the buildings would be demolished and surface soil conditions would likely change — the soil could be covered with landscaping soil and/or a house. Consequently, exposure to current surface soil conditions would not be likely under a true future residential scenario. These factors indicate that exposure pathways assessed in this HHRA would generally overestimate the risk and hazard posed to site workers and future site residents.

Determination of Exposure Point Concentrations

No UCLs were computed for COPCs in AOC 700 surface soil due to the limited sample number. As a result, maximum concentrations were applied with modification where appropriate as discussed below.

Frequency of Detection and Spatial Distribution

BEQs were reported in each of the five soil samples, and four of the reported hits exceeded the BEQ RBC. The maximum BEQ concentration was reported at location 700-003, which is closest to the eastern most railroad trestle at SWMU 44. The presence of PAHs in the area is not unexpected due to rail engine exhaust and coal dust, but is not related to waste material handling or storage within the context of RCRA. The only thallium hit report was also found at this location.

The maximum arsenic concentration was reported in sample 700-005-01 within the Building 1646 footprint. Each of the perimeter soil samples has arsenic levels below background.

Due to limited subsurface soil data, the potential for underestimation of risk/hazard related to the soil to groundwater migration pathways was considered high. Numerous chemicals, principally metals and dieldrin, were detected in surface soil above leachability based screening values. To reduce the uncertainty surrounding this issue, a supplemental groundwater evaluation was performed. Because no COPCs were identified in groundwater at well 044008, located approximately 50 feet downgradient of Building 1646, underestimation of risk/hazard is not believed to be a significant concern.

Quantification of Risk/Hazard

As indicated by the discussions above, the uncertainty inherent in the risk assessment process is great. In addition, many site-specific factors affecting the uncertainty of this assessment would upwardly bias the risk and hazard estimates. Exposure pathway-specific sources of uncertainty are discussed below.

Soil

Beryllium was not considered a COPC because the mean beryllium concentration does not exceed the RBC and the highest concentrations are comparable to the upper bound of the range of beryllium in background (based on the accuracy of the analytical method). With better analytical technology, more certainty could be give to beryllium. No COPCs were added to this HHRA based on the Wilcoxon rank sum test. Results are included in Section 5.

Because the future land use of AOC 700 is unknown, both the worker and residential exposure scenarios were assessed in this HHRA. As previously discussed, these scenarios would likely lead to overestimates of risk and/or hazard, especially under RME assumptions. An individual map was not produced for this site.

The CT assumption for residential exposure duration is nine years compared to the 30-year assumption for RME. Exposure frequency would change from 350 to 234 days per year, and applicable ingestion rates would be reduced by one-half. These changes reduce exposure estimates to 90% of those calculated under RME assumptions.

10.9.5.7 Risk Summary

The risk and hazard posed by contaminants at AOC 700 were assessed for the hypothetical RME site worker and the hypothetical RME future site resident. In surface soil, the incidental ingestion and dermal contact pathways were assessed in this HHRA. Table 10.9.16 summarizes the exposure pathway and exposure scenario risk and hazard estimates for AOC 700.

10.9.5.8 Remedial Goal Options

Soil

RGOs for the hypothetical site residential and site worker scenarios were calculated for the COCs identified as shown in Tables 10.9.17 and 10.9.18, respectively. Inclusion in an RGO table does

Table 10.9.16
Summary of Risk and Hazard for AOC 700
NAVBASE - Charleston Zone C
Charleston, South Carolina

Medium	Exposure Pathway	HI (Adult)	HI (Child)	ILCR (LWA)	HI (Worker)	ILCR (Worker)
Surface Soil	Incidental Ingestion	0.07	0.7	4E-05	0.03	4E-06
	Dermal Contact	0.015	0.0	6E-06	0.01	2E-06
Surface Soil Pathway Sum		0.09	0.7	4E-05	0.036	7E-06
Sum of All Pathways		0.1	0.7	4E-05	0.04	7E-06

Notes:
ND indicates not determined due to the lack of available risk information.
ILCR indicates incremental excess lifetime cancer risk
HI indicates hazard index

Table 10.9.17
Residential-Based Remedial Goal Options Surface Soil
AOC 700 Zone C
Naval Base Charleston
Charleston, South Carolina

Chemical	Slope Factor (mg/kg-day)-1	Reference Dose (mg/kg-day)	Unadjusted EPC mg/kg	**Hazard-Based Remedial Goal Option** **3** mg/kg	**1** mg/kg	**0.1** mg/kg	**Risk-Based Remedial Goal Option** **1E-06** mg/kg	**1E-05** mg/kg	**1E-04** mg/kg	Background Concentration mg/kg
Benzo(a)pyrene Equiv	7.3	NA	0.365	ND	ND	ND	0.06	0.6	6	NA
Arsenic	1.5	0.0003	14.3	66	21.9	2.2	0.38	3.8	38	14.2
Thallium	NA	8E-05	1.13	58.3	19.4	1.94	ND	ND	ND	ND

NOTES:

EPC exposure point concentration
NA not applicable
ND not determined
- remedial goal options were based on the residential lifetime weighted average for carcinogens and the child resident for noncarcinogens

Table 10.9.18
Worker-Based Remedial Goal Options Surface Soil
AOC 700 Zone C
Naval Base Charleston
Charleston, South Carolina

Chemical	Slope Factor (mg/kg-day)-1	Reference Dose (mg/kg-day)	Unadjusted EPC mg/kg	**Hazard-Based Remedial Goal Option** **3** mg/kg	**1** mg/kg	**0.1** mg/kg	**Risk-Based Remedial Goal Option** **1E-06** mg/kg	**1E-05** mg/kg	**1E-04** mg/kg	Background Concentration mg/kg
Benzo(a)pyrene Equiv	7.3	NA	0.365	ND	ND	ND	0.30	3.0	30	~~NA~~ .344
Arsenic	1.5	0.0003	14.3	ND	ND	ND	2.71	27.1	271	14.2

NOTES:

EPC exposure point concentration
NA not applicable
ND not determined

not necessarily indicate that remedial action is warranted. RGOs are options to be considered when making risk management decisions which, in accordance with RAGS, are not to be included in HHRAs.

10.9.6 Corrective Measures Considerations for AOC 700

For AOC 700, soil and groundwater were investigated. Although contaminants were detected in subsurface soil above their SSLs, the contaminants were not detected in groundwater indicating that the concentrations in soil are protective of groundwater. No further action is recommended for site soil.

11.0 CONCLUSIONS AND PRELIMINARY RECOMMENDATIONS

The RFI in Zone C was conducted to determine which sites, if any, designated as AOCs and/or SWMUs during the RFA pose unacceptable risk to human health or the environment (ecological concerns) and will require additional evaluation under the CMS. The conclusions reached regarding each site are based on a technical evaluation of the data following procedures outlined in the NAVBASE Charleston *Comprehensive RFI Work Plan*, regulatory guidance, and as required by the Part B permit. The NAVBASE Charleston project team has established a conservative protocol for using risk and hazard based thresholds to make preliminary recommendations for each site. The recommendations will be for no further action, additional evaluation under the CMS, additional sampling needed to complete the RFI (in which case an addendum to the report will be required). The protocol for determining which course of action may be appropriate is as follows:

- NFA - Human health risks do not exceed the $1E^{-6}$ residential ILCR and the hazard index is <1. Potential risk to ecological receptors is low based on the criteria described in Section 11.9.

- CMS - One or more of the thresholds listed above for NFA is exceeded.

- Additional Sampling Required - Data gaps exist for one or more media investigated. The data gaps are significant enough to preclude a NFA or CMS recommendation.

The recommendations are to be considered preliminary until the risk managers with the USEPA, SCDHEC, and the Navy have reviewed the data and a final decision is reached. The reason being that the USEPA and SCDHEC generally find a residential risk range of 1E-04 to 1E-06 acceptable for human health because of the conservative nature of the baseline risk assessment. This means some sites currently recommended for CMS may not require any further action once all the weight of evidence such as frequency of detection/spatial distribution, realistic exposure potential, nature of contaminants driving risk, data trends for quarterly groundwater monitoring events, etc. are considered. No further action recommendations are not acceptable for sites where a potential risk exists under a residential scenario even though an industrial reuse of the property is expected since institutional controls for the site will be required. Final recommendations and the rationale for the risk management decisions will be documented in an addendum to this report.

A summary of the preliminary recommendations for all the sites investigated in Zone C is included in Table 11.1.

Table 11.1
Zone C Site Conclusions and Preliminary Recommendations

Site Designation	Conclusion/Recommendations
SWMU 44	Recommended for CMS - Surface soil, sediment, and shallow groundwater
SWMU 47 and AOC 516	Recommended for CMS - Surface soil and shallow groundwater
AOCs 508 and 511	Recommended for CMS - Surface soil
AOCs 515 and 519	No Further Action
AOC 510	Recommended for CMS - Surface soil
AOC 512	Recommended for CMS - Surface soil
AOC 513	No Further Action
AOC 517	No Further Action
AOC 518	Recommended for CMS - Surface soil
AOC 520	No Further Action
AOC 522	Additional Sampling Needed to Complete RFI
AOC 523	Recommended for CMS - Shallow groundwater
AOC 700	Recommended for CMS - Surface soil

The following sections summarize the recommendations for each site, level of risk/hazard posed by each of the sites recommended for corrective measures, the media affected, and the chemicals driving that risk.

11.1 SWMU 44

SWMU 44 is the coal storage yard which began operations in the 1940s. It was used for unloading coal railcars and for the intermediate storage of coal before use at the steam-generation plant. For purposes of risk assessment, SWMU 44 was divided into four areas. All four areas have been recommended for additional evaluation under the CMS due ILCR and/or HI values which exceed the baseline decision making criteria explained in Section 11.0. Subsequent to completion of the RFI field work, an interim corrective measure consisting of a removal of visible coal was completed at the site. Table 11.2 lists the affected media, the risk/hazard, and the chemicals that drove the risk prior to completion of the RFI.

Table 11.2
SWMU 44
Conclusion Summary

Affected Media	Unacceptable Risk/Hazard in Future Residential Scenario	Chemicals Driving Risk
Area 1 Surface Soil	Yes - ILCR = 3E-04 Yes - HI = 5.8	arsenic, beryllium, and BEQs arsenic
Area 2 Surface Soil	Yes - ILCR = 4E-04 Yes - HI = 6.7	arsenic, beryllium, thallium, and BEQs arsenic
Area 3 Surface Soil	Yes - ILCR = 2E-04 Yes - HI = 3.3	arsenic, beryllium, and BEQs aluminum, arsenic, and thallium

Table 11.2
SWMU 44
Conclusion Summary

Affected Media	Unacceptable Risk/Hazard in Future Residential Scenario	Chemicals Driving Risk
Area 4 Surface Soil	Yes - ILCR = 1E-05 No - HI =0.1	BEQs
Sitewide Shallow groundwater	Yes - ILCR = 1.8E-03 Yes - HI = 33	arsenic and beryllium arsenic, beryllium, and manganese

11.2 SWMU 47 and AOC 516

AOC 516 is just west of SWMU 44 and includes Building 233. This area was used for spray washing vehicles and equipment from 1972 until the 1980s, but more recently it was used for recharging lead batteries. SWMU 47 was used as a burning dump during the 1920s where various types of wastes (including medical waste) were reportedly incinerated. Currently the site includes Buildings NSC-62, NSC-66, and NSC-67 and the surrounding asphalt and grassy areas.

The primary human health risk drivers identified in surface soil at these sites were BEQs and arsenic. The projected risk for human health under a future residential scenario was calculated at 6E-05. Due to the nature of past site operations at SWMU 47, lead was recognized initially as a potential concern. As would naturally be expected, lead was detected at all 16 surface soil locations sampled during the RFI. The maximum reported concentration of 1,120 mg/kg was reported at soil boring 047SB007. Due to their proximity to the former battery charging operations, a focused emphasis was placed borings 047SB007, 516SB001, and 516SB002 to determine a reasonable maximum exposure. The mean lead concentrations for these three locations was 385 mg/kg. Since this "hot spot" mean falls below the residential cleanup goal of 400 mg/kg, chronic soil pathway exposures are not expected to pose a significant health threat to potential future child residents.

The results for the first quarter of groundwater sampling reported a lead concentration in monitoring well 047GW001 of 467 μg/L which was significantly above the TTAL of 15 μg/L. Lead was nondetect during rounds 2, 3 and 4 for the same well and for all additional site wells lead was not detected above the TTAL in any quarter. The site specific risk assessment identified arsenic as a COC for shallow groundwater. Arsenic was detected above its MCL of 50 μg/L in well 047GW011 during rounds 2, 3, and 4. Concentrations detected in this well over the four quarters ranged from 46.3 to 164 μg/L.

These sites have been recommended for additional evaluation under the CMS due to a risk greater than 1E-06 and a HI >1. Table 11.3 lists the affected media, the risk/hazard, and the chemicals that drive the risk.

Table 11.3
AOC 516 and SWMU 47
Conclusion Summary

Affected Media	Unacceptable Risk/Hazard in Future Residential Scenario	Chemicals Driving Risk
Surface soil	Yes - ILCR = 6E-05 Yes - HI = 1.1	BEQs, arsenic arsenic
Shallow groundwater	Yes - ILCR = 2E-02 Yes - HI = 26	arsenic arsenic

11.3 AOCs 508 and 511

AOC 508 was an incinerator (Incinerator 19), operated in the 1920s. AOC 508 is currently a grassy area west of Avenue H. AOC 511 is the site of former Building 16. This building was used to store oil from approximately 1922 until 1955. Currently this site is also a vacant grassy area.

BEQs and chlorinated pesticides were identified as the primary risk drivers in surface soil which contributed to a risk of 3E-05 for the sites. Several of the pesticides were reported in the subsurface at concentrations which only minimally exceeded their respective SSLs. Two monitoring wells were installed and samples collected were analyzed for pesticides. None were detected so it was concluded the levels present in soil are sufficiently low enough to protect groundwater. It should be noted that during the installation of monitoring well NBCC-511-002, a strong petroleum odor was encountered. In addition, during the utility clearance of the area prior to drilling, a subsurface metallic anomaly which resembled a UST was identified. It is recommended that the area be investigated further under the auspices of the South Carolina Underground Storage Tank program.

The site is recommended for additional evaluation under the CMS based on risk greater than 1E-06 in surface soil. Table 11.4 lists the affected medium, the risk/hazard, and the chemical(s) that drive the risk.

Table 11.4
AOCs 508 and 511
Conclusion Summary

Affected Medium	Unacceptable Risk/Hazard in Future Residential Scenario	Chemicals Driving Risk
Surface soil	Yes - ILCR = 3E-05 No - HI =0.2	BEQs, dieldrin, chlordane, and DDT

11.4 AOCs 515 and 519

AOC 515 is a gravel parking area approximately 100 feet east of Building NH-55 that operated as an incinerator in the 1920s and as a paint shop in the 1930s. AOC 519 is a gravel parking area on the east side of Building NH-55. A boiler house operated onsite from 1922 until 1929. No further action is required based on the analytical results and risk assessment since no COCs were identified.

11.5 AOC 510

AOC 510 has been used for several purposes throughout its history. Building NH-21 was first used as a fireproof warehouse (1919-1947), a paint shop (1955-1962), and a storage area (1962-1977). BEQs were detected in surface soil at two locations that exceeded the RBC of 88 μg/kg with the maximum detection being 583 μg/kg. Nonetheless, the BEQ concentrations drove a surface soil risk of 2E-06.

The groundwater portion of the risk assessment was based on the first quarter sample results and no COCs were identified. However, further review of the remaining 3 quarters of data revealed that selenium and thallium concentrations were above MCLs in the fourth quarter which was the only time they were detected. There is no evidence to suggest that selenium and thallium are site related; therefore, for purposes of the AOC 510 assessment they have been eliminated from consideration. They will be retained for further evaluation by the project team as part of bigger picture zone and/or base wide issue of inorganics in groundwater.

AOC 510 has been recommended for additional evaluation under the CMS based on risk greater than 1E-06 in surface soil. Table 11.5 lists the affected medium, the risk/hazard, and the chemical(s) that drive the risk.

Table 11.5
AOC 510
Conclusion Summary

Affected Media	Unacceptable Risk/Hazard in Future Residential Scenario	Chemicals Driving Risk
Surface soil	Yes - ILCR = 2E-06 No - HI = 0.9	BEQs

11.6 AOC 512

AOC 512 was an incinerator which operated from 1943 until 1958. Currently, the site is a grassy area near Building 1079. BEQs and beryllium were identified in surface soil at levels that pose a risk marginally greater than 1E-06 to human health.

Lindane was detected in the subsurface at 8.4 μg/kg which minimally exceeds the SSL of 3 μg/kg. At the request of the project team two monitoring wells were installed and samples analyzed for chlorinated pesticides. None were detected and it was concluded the levels present in soil are sufficiently low enough to protect groundwater. AOC 512 groundwater is recommended for no further action because contaminants detected in soil were not detected in groundwater indicating the detected levels are sufficiently low to protect groundwater.

AOC 512 surface soil is recommended for CMS based on the risk greater that 1E-06. Table 11.6 lists the affected medium, the risk/hazard, and the chemical(s) that drive the risk.

Table 11.6
AOC 512
Conclusion Summary

Affected Medium	Unacceptable Risk/Hazard in Future Residential Scenario	Chemicals Driving Risk
Surface soil	Yes - ILCR = 6E-06 No - HI = 0.2	BEQs and beryllium

11.7 AOC 513

AOC 513 operated as a morgue during the early 1920s. Currently, this site is a grass covered area southwest of Building NH-55. The waste disposal practices of this facility are unknown. No further action is recommended based on the analytical results and risk assessment. No COCs were identified.

11.8 AOC 517

AOC 517 is the former Indoor Firing Range, Building M-192, which operated from 1959 until 1974. No COCs were identified during the RFI therefore a CMS is not recommended. Wipe samples collected inside the building confirmed the presence of lead on wall surfaces which may need to be addressed as an industrial hygiene related matter depending on the intended reuse of the building.

11.9 AOC 518

Coal was stored in bins at AOC 518 from 1926 until 1937. This site is currently a gravel and asphalt parking area and is partially covered by Building M-1257. Chlordane was detected in soil near the building footing which is likely the result of a pest control application. Additional soil samples were collected to define the extent of the chlordane detection and also to assess if it was a widespread occurrence; however, chlordane was not detected. A CMS is recommended for this site based on the fact the isolated nature of the chlordane hit still poses a potential risk greater than 1E-06.

Table 11.7
AOC 518
Conclusion Summary

Affected Medium	Unacceptable Risk/Hazard in Future Residential Scenario	Chemicals Driving Risk
Surface soil	Yes - ILCR = 3E-06 No - HI = 0.6	Chlordane

11.10 AOC 520

AOC 520 was a garbage storehouse for the barracks from the 1920s until the 1940s. Currently, the site is an asphalt parking area just north of Building M-17. No further action is recommended based on the analytical results and risk assessment. No COCs were identified.

11.11 AOC 522

AOC 522 is the site of former Building 1252, a grease and wash building, located at the southeast corner of Building 198, near the loading docks. Soil was the only medium sampled during the RFI and no COCs were identified. Methylene chloride was detected in the subsurface and exceeded it's SSL at three locations. As a result of questions raised by the project team, additional sampling is needed to investigate the potential for methylene chloride to impact the groundwater. Two DPT points will be installed to collect groundwater samples for VOC analysis to confirm the presence or absence of methylene chloride in groundwater. Upon receipt, the data along with a recommendation for further course of action will be submitted in an addendum to this report.

11.12 AOC 523

AOC 523 was formerly a gas station (M-1234), which operated from 1958 until 1962. Currently, the site is covered by the southeastern portion of Building 198. Evaluation of the data did not identify any COCs in surface soil.

Aluminum, arsenic, and manganese were identified as COCs in shallow groundwater. Of the three, only arsenic has an MCL. A review of all four quarters of groundwater data indicated that no exceedances of the 50 μg/L occurred and the results decreased to non-detect in the third and fourth quarters. As noted previously, the risk assessment was based solely on the first quarter results. Arsenic drove a risk greater than 1E-06 and a HI >1. Similar to AOC 510 above, there is no evidence to suggest the COCs are site related and it may be more prudent for the project team to address the inorganics in groundwater on a zone and/or basewide scale. This site is tentatively recommended for CMS on the basis of the first quarter groundwater risk and hazard exceeding the established minimum thresholds for CMS consideration.

Table 11.8
AOC 523
Conclusion Summary

Affected Medium	Unacceptable Risk/Hazard in Future Residential Scenario	Chemicals Driving Risk
Shallow Groundwater	Yes - ILCR = 6E-04 Yes - HI = 18	Arsenic Arsenic

11.13 AOC 700

AOC 700 is the site of building 1646 which was formerly used as a golf course maintenance facility. Building 1646 is located west of Avenue D and north of Hunt Street.

BEQs and arsenic were the primary compounds contributing to a risk greater than 1E-06 in surface soil. Concerns were raised by the project team regarding the presence of the pesticide dieldrin and several inorganics in the subsurface at concentrations marginally exceeding their respective SSLs. To address the issue, groundwater was sampled for pesticides and inorganics at monitoring well NBCC-044-008 which is approximately 50 feet downgradient of the site. No pesticides were detected. Inorganics in groundwater in this area are already proposed for further evaluation as part of the CMS recommended for SWMU 44. No further action for groundwater with respect to AOC 700 is recommended since it is being addressed under SWMU 44.

AOC 700 is tentatively recommended for CMS on the basis of a surface soil risk greater than 1E-06.

Table 11.9
AOC 700
Conclusion Summary

Affected Medium	Unacceptable Risk/Hazard in Future Residential Scenario	Chemicals Driving Risk
Surface soil	Yes - ILCR = 4E-05 No - HI = 0.7	BEQs, arsenic

11.14 Ecological Risk Summary

As described in Section 8.0, Zone C was segregated into three "subzones" for purposes of the ERA. Table 11.9 identifies sites associated with each subzone which were illustrated on Figure 8.2 found in Section 8.0. Risk to ecological receptors was evaluated for ECPCs in surface soil, surface water, and sediment at sub-zone C-1 and for soil only at sub-zones C-2 and C-3. This is primarily because of the change in scope to the Final Zone J RFI Work Plan. By the time these changes were implemented, field work for Zone C had already been completed and report preparation underway, thus creating data gaps for sediment and surface water in sub-zones C-2 and C-3. Risk associated with exposure to ECPCs in surface soil was evaluated for terrestrial wildlife based on a model that predicts the amount of contaminant exposure via the diet and incidental ingestion of soil. The risk evaluation is based on a comparison of predicted doses for representative wildlife species with doses representing thresholds for both lethal and sublethal effects (RTVs). Risk for soil invertebrates and plants was evaluated based on qualitative comparison to literature effects levels for taxonomic groups similar to those potentially inhabiting Zone C. Risk for aquatic organisms were evaluated by calculating HQs from benchmark values that are either promulgated or proposed by federal and state regulatory agencies.

Table 11.10
AOCs/SWMUs associated with Zone C Subzones

AOC/SWMU	Description	Potentially Impacted Areas Outside Subzone
	Subzone C-1	
SWMU 44	Former Coal Storage Yard	Noisette Creek/Cooper River
	Subzone C-2	
AOC 512	Former Incinerator Building	Noisette Creek/Cooper River
AOC 509	Hazardous Flammable Storage (Bldg. 1079)	Noisette Creek/Cooper River

Table 11.10
AOCs/SWMUs associated with Zone C Subzones

AOC/SWMU	Description	Potentially Impacted Areas Outside Subzone
	Subzone C-3	
AOC 504**	Railroad System (Zone L)	Cooper River

Note:
** AOC 504 railroads and their associated impacts are being investigated as part of the Zone L RFI. Due to the lack of identified contaminant pathways from Zone C AOC/SWMUs to Subzone C-3, no sampling has been conducted as part of the Zone C ERA.

11.14.1 Terrestrial Wildlife

No risk potential for lethal effects to terrestrial wildlife exist based on soil ECPCs within sub-zones C-1, C-2, and C-3. All HQ and HI values calculated for each of the representative wildlife species within each sub-zones were less than one (Tables 8.11a, 8.12a, 8.13a).

Potential sub-lethal effects to lower level vertebrates (shrew) exist at sub-zones C-1, C-2, and C-3 from exposure to ECPCs in surface soil. Although risk potential produced by the model contradicts some literature information related to arsenic transfer to small mammals, measurement of tissue concentrations or in situ bioaccumulation studies are needed to assess the actual potential for impacts to small mammals.

Potential sub-lethal effects to passerine birds from exposure to ECPCs in soil exist at C-2 and C-3. Maximum DDT concentrations were primarily responsible for risk at sub-zone C-2. At C-3 not a single constituent had an HQ above one. Cadmium and mercury contributed significant HI values resulting in potential risk. Although literature information appears to be accurate and supportive of the model, in situ bioaccumulation studies at both sites would help reduce the uncertainty inherent in the model prediction.

11.14.2 Vegetation

A potential risk to woody seedlings and young herbaceous species exist at sub-zones C-1 and C-2. At C-1, maximum concentrations of copper and arsenic constitute the risk. At C-2 copper, lead, manganese, and zinc concentrations are above levels reported in literature. Effects from organic concentrations could not be assessed.

No potential risk to vegetation exist at sub-zone C-3 based on inorganic concentrations. Organic effects could not be assessed.

11.14.3 Aquatic Wildlife

Sub-zone C-1 surface water quality does not appear to be at risk or significantly impacted.

A potential risk to aquatic receptors exist in sediments at sub-zone C-1 because HQ values are greater than one for arsenic, copper, lead, mercury, and nickel. Actual risk to receptors within the water body may be lower than that implied by using the SSV in the screening assessment. Specific impacts at C-1 to receptors for both water and sediment would be difficult to determine.

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13.0 SIGNATORY REQUIREMENT

Condition I.E. of the Hazardous and Solid Waste Amendments (HSWA) portion of RCRA Part B Permit (EPA SCO 170 022 560) states: *All applications, reports, or information submitted to the Regional Administrator shall be signed and certified in accordance with 40 CFR §270.11.* The certification reads as follows:

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

11/14/97

Officer in Charge
Caretaker Site Office

Date

Appendix A

Zone C

Lithologic Boring Logs
and
Well Construction Diagrams

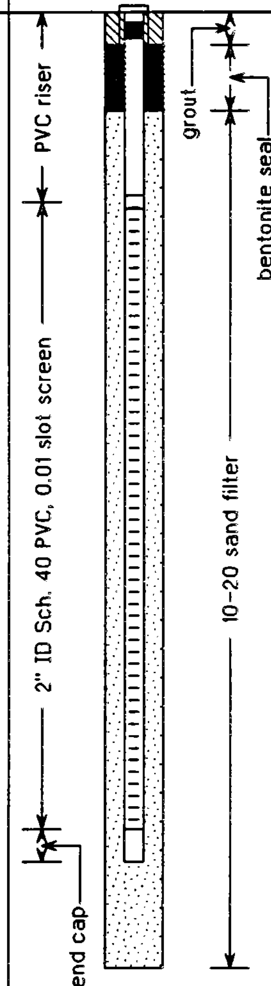
EnSafe/Allen & Hoshall

Monitoring Well NBCC047001

Project: *Zone C – Naval Base Charleston*	Coordinates: *2315367.46 E, 376790.03 N*
Location: *Charleston, SC*	Surface Elevation: *8.3 feet msl*
Started at *0755 on 4-11-95*	TOC Elevation: *8.35 feet msl*
Completed at *0840 on 4-11-95*	Depth to Groundwater: *4.17 feet TOC* Measured: *6-21-95*
Drilling Method: *4.25" ID (7.5" OD) HSA with split spoon*	Groundwater Elevation: *4.18 feet msl*
Drilling Company: *Alliance Environmental*	Total Well Depth: *12.9 feet bgs*
Geologist: *Peter Bayley*	Well Screen: *2.9 to 12.9 feet bgs*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
								Surface conditions: Asphalt	
							SP/SM	Sand: brown-black, very fine to fine, some silt, moist to wet, soft.	5.3
5			1	100	0				3.3
							SP	6" piece of wood in split spoon with brown, very fine to fine sand soft, wet.	.3 / 0
10			2	15	0				
							SP	4"Wood debris, with brown, very fine to fine, sand, soft, wet.	-4.7 / -5
15			3	33	0				
20									

WELL DIAGRAM



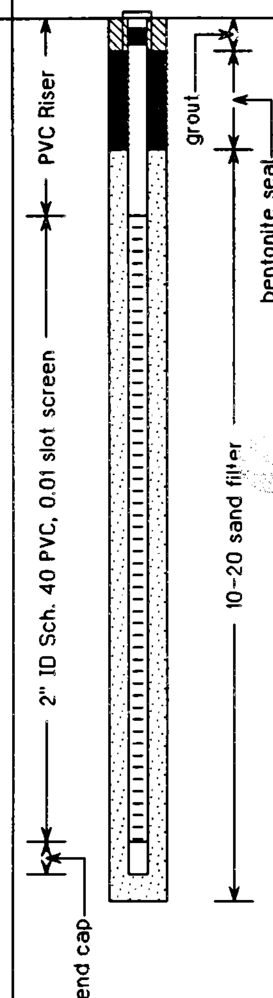
EnSafe/Allen & Hoshall

Monitoring Well NBCC047002

Project: *Zone C – Naval Base Charleston*	Coordinates: *2315778.43 E, 376925.26 N*
Location: *Charleston, SC*	Surface Elevation: *10.1 feet msl*
Started at *1530 on 4-5-95*	TOC Elevation: *9.80 feet msl*
Completed at *1630 on 4-5-95*	Depth to Groundwater: *6.67 feet TOC* Measured: *6-21-95*
Drilling Method: *4.25" ID (7.5" OD) HSA with split spoon*	Groundwater Elevation: *Unknown feet msl*
Drilling Company: *Alliance Environmental*	Total Well Depth: *13 feet bgs*
Geologist: *Peter Bayley*	Well Screen: *3 to 13 feet bgs*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
								Surface conditions: Asphalt	
							SP/SM	Sand: brown, very fine, silty, some clay, damp, piece of wood, grading into black-brown sand with very thin laminae and light brown very fine to fine, silty, damp sand.	7.1 5.9
5			1	58	0				
							SP/SM	Sand: black to dark brown, very fine, some silt, damp, with 1" dark brown, firm, plastic clay stringer at 8'.	2.1 1.8
							SP	Sand: gray with yellow orange Fe-Ox mottling decreasing at depth, very fine to fine, soft, wet.	.9
10			2	63	0				
							SP/SW	Sand: buff to white with Fe-Ox stain at base, very fine to fine/medium, soft, wet; upper 0.4' gray sand with black mottling, very fine to fine, slightly plastic, some silt, soft, wet.	-2.9 -4.9
15			3	100	0				
20									

WELL DIAGRAM



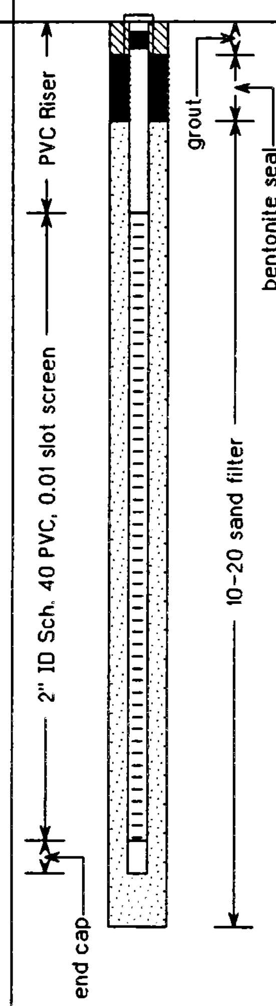
EnSafe/Allen & Hoshall

Monitoring Well NBCC047003

Project: *Zone C – Naval Base Charleston*	Coordinates: *2315848.34 E, 377037.00 N*
Location: *Charleston, SC*	Surface Elevation: *9.1 feet msl*
Started at *1515 on 4-10-95*	TOC Elevation: *9.26 feet msl*
Completed at *1615 on 4-10-95*	Depth to Groundwater: *6.12 feet TOC* Measured: *6-21-95*
Drilling Method: *4.25" ID (7.5" OD) HSA with split spoon*	Groundwater Elevation: *3.14 feet msl*
Drilling Company: *Alliance Environmental*	Total Well Depth: *12.9 feet bgs*
Geologist: *Peter Bayley*	Well Screen: *2.9 to 12.9 feet bgs*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
								Surface conditions:	
							CH	Clay: yellow-brown, silty with some very fine sand, marl, firm, plastic, moist to wet.	6.1 / 4.5
5			1	78	0				
							CH	Clay: gray with some yellow-brown, some silt, pebbly base, soft, plastic, wet, grading to yellow-brown, silty, sandy clay, firm, marly.	1.1 / .4
							SP/SW	Sand: light gray to brown, very fine to fine/medium, trace of silt, soft, wet, with wood debris.	.6
10			2	83	0				
							SP/SW	Sand: as above	3.9 / 4.3
							SP/SM	Sand: dark brown with faint light brown laminae, very fine to fine, some silt, soft, wet; color changes to brown and light brown at 13.6' and blue-gray at 13.9'.	5.2
							CL	Clay: blue-gray, some silt, trace of very fine sand, somewhat plastic, firm.	5.4
15			3	75	0				
20									

WELL DIAGRAM



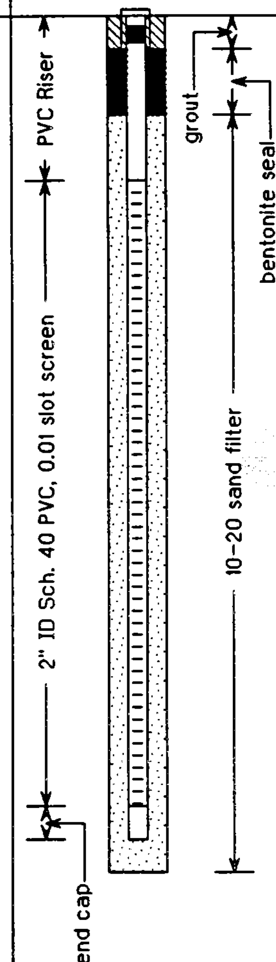
EnSafe/Allen & Hoshall

Monitoring Well NBCC047004

Project: *Zone C – Naval Base Charleston*	Coordinates: *2315744.07 E, 377383.02 N*
Location: *Charleston, SC*	Surface Elevation: *9.2 feet msl*
Started at *0845 on 4-10-95*	TOC Elevation: *9.08 feet msl*
Completed at *1005 on 4-10-95*	Depth to Groundwater: *5.54 feet TOC* Measured: *6-21-95*
Drilling Method: *4.25" ID (7.5" OD) HSA with split spoon*	Groundwater Elevation: *3.54 feet msl*
Drilling Company: *Alliance Environmental*	Total Well Depth: *12.5 feet bgs*
Geologist: *Peter Bayley*	Well Screen: *2.5 to 12.5 feet bgs*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
								Surface conditions:	
							SP	Sand: light brown, very fine to medium, soft, loose, damp.	6.2 / 5.9
							SC / CL	Sand; brown, very fine to fine, some silt, trace of clay with 2" gray to orange, sandy clay stringer at 3.3'.	5.6
5			1	92	0		SM / SC	Sand: dark brown; very fine to fine, some silt, soft, moist to wet.	4.4
							SP	*Wood pieces, gray, large*; with some brown fine to medium sand.	1.2 / .7
			2	25	0				
10							SP	*Wood*; spoon wet and lined with light brown, very fine sand.	.8 / -1
			3	13	0				
							SP	Sand: light gray, very fine to medium, trace of silt, wet, soft, with 7" wood; bottom 2" consists of very fine to fine, light green-gray sand, soft, wet.	-3.8 / -5.2
15			4	71	0				
20									

WELL DIAGRAM



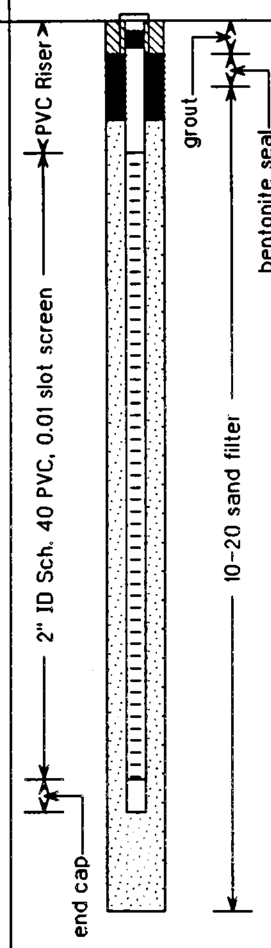
EnSafe/Allen & Hoshall

Monitoring Well NBCC047005

Project: *Zone C – Naval Base Charleston*	Coordinates: *2315600.60 E, 377393.31 N*
Location: *Charleston, SC*	Surface Elevation: *8.7 feet msl*
Started at *1110 on 4-5-95*	TOC Elevation: *11.14 feet msl*
Completed at *1230 on 4-5-95*	Depth to Groundwater: *7.30 feet TOC* Measured: *6-21-95*
Drilling Method: *4.25" ID (7.5" OD) HSA with split spoon*	Groundwater Elevation: *3.84 feet msl*
Drilling Company: *Alliance Environmental*	Total Well Depth: *12 feet bgs*
Geologist: *Peter Bayley*	Well Screen: *2 to 12 feet bgs*

DEPTH IN FEET	SAMPLE NO.	% RECOVERY	PID (ppm)	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
					Surface conditions: soil and gravel	
				SM/SP	Sand: dark brown to gray, very fine to fine, trace to some silt, trace to some clay, soft, wet at 3.3'.	5.7 / 4.1
5	1	78	0			
				SP	Sand: gray, very fine to fine, trace silt, soft, wet.	.7 / .6
10	2	66	0			
				SP	Sand: as above.	-4.3 / -5.9
15	3	78	0	SP	Sand: as above.	-6.3
	4	100	0			-8.3
20						

WELL DIAGRAM



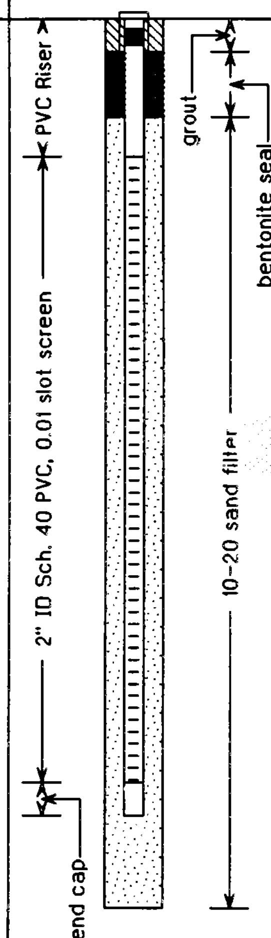
EnSafe/Allen & Hoshall

Monitoring Well NBCC047006

Project: *Zone C – Naval Base Charleston*	Coordinates: *2315164.71 E, 377240.48 N*
Location: *Charleston, SC*	Surface Elevation: *9.8 feet msl*
Started at *1330 on 4-5-95*	TOC Elevation: *12.27 feet msl*
Completed at *1445 on 4-5-95*	Depth to Groundwater: *7.53 feet TOC* Measured: *6-21-95*
Drilling Method: *4.25" ID (7.5" OD) HSA with split spoon*	Groundwater Elevation: *4.74 feet msl*
Drilling Company: *Alliance Environmental*	Total Well Depth: *12.1 feet bgs*
Geologist: *Peter Bayley*	Well Screen: *2.1 to 12.1 feet bgs*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
								Surface conditions: soil and grass	
							SP	Sand: brown to dark gray, very fine to fine with some medium, trace of silt, soft, wet at 3.5'.	6.8 / 6.1
5			1	37	0				
10			2	0	0		SP	Sand: gray with orange FeOx banding in upper 3", very fine to fine with trace medium, trace silt, soft, wet; more brown in upper 5".	2 / 1.7
			3	75	0				
							SP	Sand: brown to dark brown, very fine to fine, trace silt, soft, wet, some granule to pebbly layer at 13.2-13.4'.	3.2 / 3.9
15			4	37	0				
20									

WELL DIAGRAM



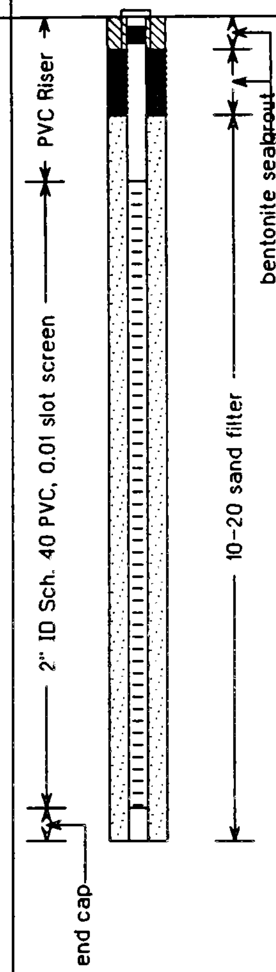
EnSafe/Allen & Hoshall

Monitoring Well NBCC047007

Project: *Zone C – Naval Base Charleston*	Coordinates: *2315173.34 E, 377072.00 N*
Location: *Charleston, SC*	Surface Elevation: *9.4 feet msl*
Started at *1730 on 4-12-95*	TOC Elevation: *9.28 feet msl*
Completed at *1835 on 4-12-95*	Depth to Groundwater: *4.47 feet TOC* Measured: *6-21-95*
Drilling Method: *4.25" ID (7.5" OD) HSA with split spoon*	Groundwater Elevation: *4.81 feet msl*
Drilling Company: *Alliance Environmental*	Total Well Depth: *12.5 feet bgs*
Geologist: *John Hardy*	Well Screen: *2.5 to 12.5 feet bgs*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
5			1	100	0		SP	Sand: dark brown to brownish-black, very fine to silt, dry, grading to yellowish-tan to orangish-yellow, medium, wet at 3.4'.	6.4 / 4.4
10			2	100	0		SP	Sand: varigated yellowish-orange and yellowish-tan, some dark orange mottling, medium to coarse with trace fine, saturated.	1.4 / .6
15			3	100	0		SP	Sand: reddish-orange, coarse, litte to no fines, saturated.	-3.6 / -5.6
20									

WELL DIAGRAM



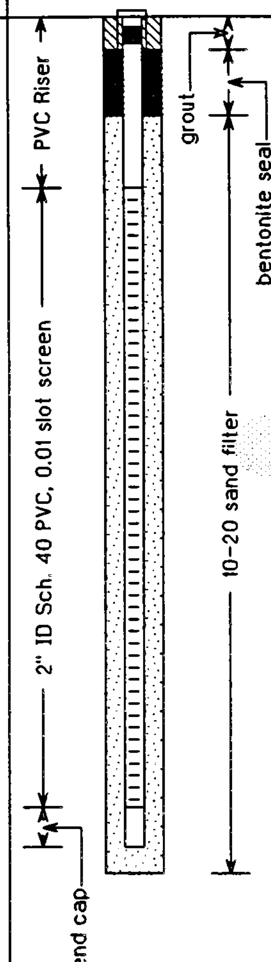
EnSafe/Allen & Hoshall

Monitoring Well NBCC047008

Project: *Zone C – Naval Base Charleston*	Coordinates: *2315247.58 E, 376855.51 N*
Location: *Charleston, SC*	Surface Elevation: *9.4 feet msl*
Started at *0830 on 4-12-95*	TOC Elevation: *9.16 feet msl*
Completed at *0930 on 4-12-95*	Depth to Groundwater: *4.58 feet TOC* Measured: *6-21-95*
Drilling Method: *4.25" ID (7.5" OD) HSA with split spoon*	Groundwater Elevation: *4.58 feet msl*
Drilling Company: *Alliance Environmental*	Total Well Depth: *12.6 feet bgs*
Geologist: *Peter Bayley*	Well Screen: *2.6 to 12.6 feet bgs*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
								Auger cuttings from 0-2.5 ': Sand: black to brown, very fine to fine, dry wood at 2' bgs, gray, silty, moderately plastic clay from 2-2.5'.	6.4
							CH	Clay: gray with a 1" yellow basal silt layer, some silt, firm, plastic, wet.	5.7
							SP / SM	Sand: dark brown, very fine to fine, some silt, trace of clay, soft, moist.	5
5			1	71	0.4				
							SP	Sand: brown, very fine to fine, trace of silt, soft, wet.	1.4 / .9
							CH	Clay: olive-gray with streaks of yellow marl, some silt, firm, plastic, moist to wet.	.6
							SP	Sand: dark brown, very fine to fine, some silt, trace clay, soft, wet. soft.	.4
10			2	50	0.4				
							SP	Sand: brown, very fine to fine, trace of silt, soft, wet, interbedded with 3" dark gray, silty clay, some sand, plastic, wet.	-3.6
15			3	100	0.9				-5.6
20									

WELL DIAGRAM



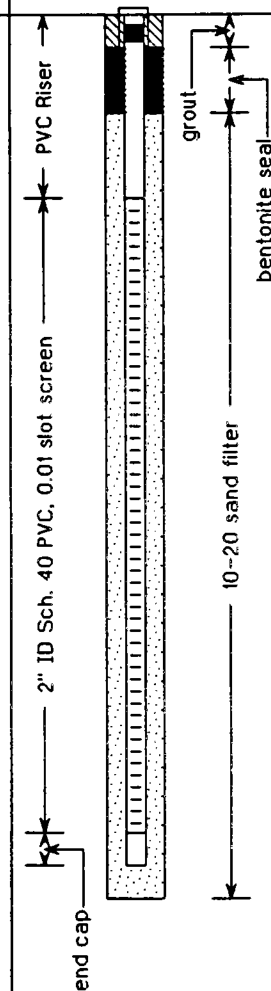
EnSafe/Allen & Hoshall

Monitoring Well NBCC047009

Project: *Zone C – Naval Base Charleston*	Coordinates: *231534141 E, 37696136 N*
Location: *Charleston, SC*	Surface Elevation: *8.8 feet msl*
Started at *0910 on 4-11-95*	TOC Elevation: *8.62 feet msl*
Completed at *1020 on 4-11-95*	Depth to Groundwater: *4.45 feet TOC* Measured: *6-21-95*
Drilling Method: *4.25" ID (7.5" OD) HSA with split spoon*	Groundwater Elevation: *4.17 feet msl*
Drilling Company: *Alliance Environmental*	Total Well Depth: *12.9 feet bgs*
Geologist: *Peter Bayley*	Well Screen: *2.9 to 12.9 feet bgs*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
								Surface conditions:	
							CH	Clay: grayish-black to yellow-brown, some silt, plastic, firm, moist, calcareous.	5.8
							SM	Sand: brown to black, very fine to fine, soft, wet with 1" black silt lamination at 3.4'.	5.4 5.1
5			1	33	0				
							CH	Clay: gray, silty, some very fine sand, plastic, soft, wet, some wood	.8 .6
							SP	Sand: brown, very fine to fine, some silt, soft, wet, slight septic odor.	.4
10			2	62	0				
							SP	Sand: as above with more silt; *Shoe blocked by 2" chunks of red brick.*	4.2 4.4
15			3	8	0				
20									

WELL DIAGRAM



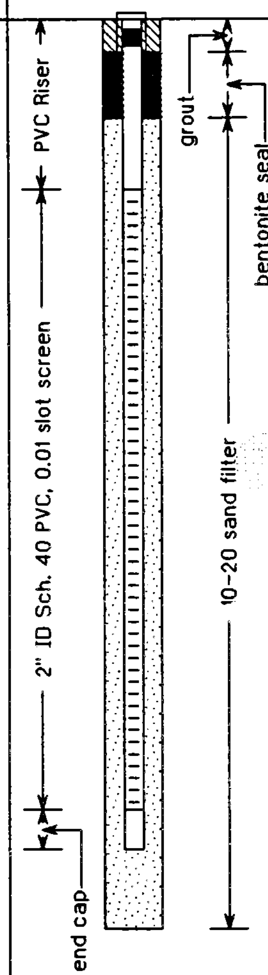
EnSafe/Allen & Hoshall

Monitoring Well NBCC047010

Project: *Zone C – Naval Base Charleston*	Coordinates: *2315337.74 E, 377138.844 N*
Location: *Charleston, SC*	Surface Elevation: *8.4 feet msl*
Started at *1010 on 4-12-95*	TOC Elevation: *8.30 feet msl*
Completed at *1230 on 4-12-95*	Depth to Groundwater: *4.09 feet TOC* Measured: *6-21-95*
Drilling Method: *4.25" ID (7.5" OD) HSA with split spoon*	Groundwater Elevation: *4.21 feet msl*
Drilling Company: *Alliance Environmental*	Total Well Depth: *12.6 feet bgs*
Geologist: *Peter Bayley*	Well Screen: *2.6 to 12.6 feet bgs*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
								Surface conditions:	
							SP SM	Sand: brown with some yellow, very fine to fine, silty, trace of clay, damp to moist. *Shoe plugged.*	5.4 / 5.1
5			1	17	0				
							ML	Silt: dark brown to black, some very fine sand, trace of clay, wet, soft. *Split spoon contained a piece of wood and a root; sour odor.*	.4 / -.2
							SP	Sand: greenish-gray, very fine to fine, trace silt, soft, wet.	-.6
10			2	50	0				
							SP SM	5" *Piece of wood; sour odor. Bottom of auger flights:* Sand: as above.	-4.6 / -5
15			3	15	0				
20									

WELL DIAGRAM



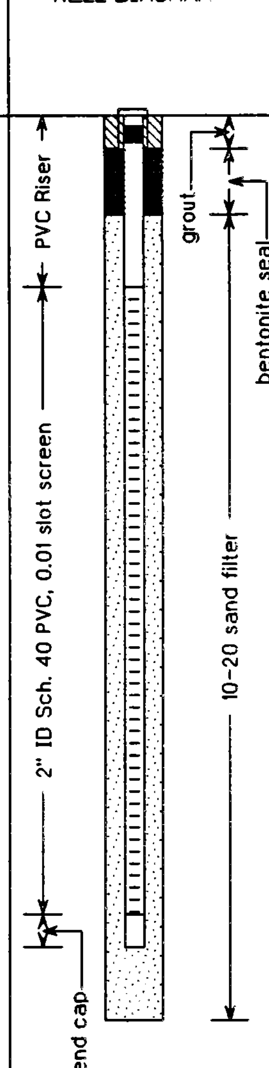
EnSafe/Allen & Hoshall

Monitoring Well NBCC047011

Project: *Zone C – Naval Base Charleston*	Coordinates: *231568192 E, 377238.78 N*
Location: *Charleston, SC*	Surface Elevation: *8.3 feet msl*
Started at *1350 on 4-10-95*	TOC Elevation: *8.21 feet msl*
Completed at *1445 on 4-10-95*	Depth to Groundwater: *4.60 feet TOC* Measured: *6-21-95*
Drilling Method: *4.25" ID (7.5" OD) HSA with split spoon*	Groundwater Elevation: *3.61 feet msl*
Drilling Company: *Alliance Environmental*	Total Well Depth: *12.6 feet bgs*
Geologist: *Peter Bayley*	Well Screen: *2.6 to 12.6 feet bgs*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
								Surface conditions:	
							SP	Sand: light brown, very fine to medium, trace of silt, moist to soft, wet.	5.3
5			1	75	0				3.6
							SP	Sand: brown, very fine to fine, trace of silt, soft, wet.	.3
							CH	Clay: dark gray with dark brown mottling, plastic, stiff, some shell fragments.	.1
10			2	50	0				.7
							SP	Sand: brown, very fine to fine, trace of silt, shell fragments, soft, wet.	-4.7
							CH	Clay: dark gray to black, very stiff, plastic, moist.	-4.9
							SP	Sand: gray with Fe-Ox staining, very fine to medium, soft, wet.	-5.3
15			3	85	0				-6.5
20									

WELL DIAGRAM



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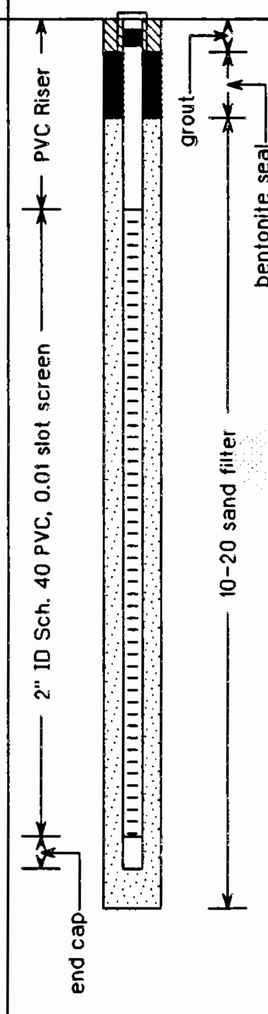
Monitoring Well NBCC047012

Project: *Zone C – Naval Base Charleston*	Coordinates: *2315727.68 E, 377070.62 N*
Location: *Charleston, SC*	Surface Elevation: *8.6 feet msl*
Started at *1040 on 4-10-95*	TOC Elevation: *8.56 feet msl*
Completed at *1145 on 4-10-95*	Depth to Groundwater: *5.15 feet TOC* Measured: *6-21-95*
Drilling Method: *4.25" ID (7.5" OD) HSA with split spoon*	Groundwater Elevation: *3.41 feet msl*
Drilling Company: *Alliance Environmental*	Total Well Depth: *12.9 feet bgs*
Geologist: *Peter Bayley*	Well Screen: *2.9 to 12.9 feet bgs*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
								Surface conditions:	
							SP/SW	Sand: orange to light brown, very fine to medium, trace silt, soft, moist to wet.	5.6
5			1	83	0				3.9
							SP/SW	Sand: dark brown, very fine to medium, trace silt, wet, shell fragments.	.6
10			2	75	0				-.8
							SP	Sand: brown, very fine to medium, trace silt, wet, shell fragments with 2" clay lense, dark brown to gray, plastic, stiff.	-4.4
							SP/SW	Sand: orange and brown, thin laminations, wet, some thin clay layers (<1 cm).	-5.1
15			3	75	0				-5.9
20									

WELL DIAGRAM



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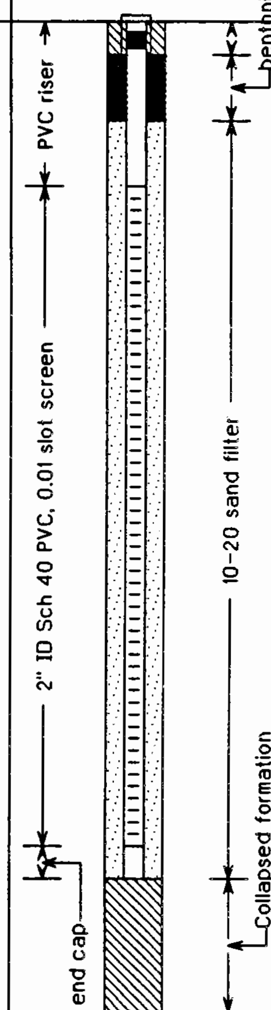
Monitoring Well NBCC047013

Project: *Zone C – Naval Base Charleston*	Coordinates: *2315593 E, 376964 N N*
Location: *Charleston, SC*	Surface Elevation: *9.3 feet msl*
Started at *1450 on 4-17-95*	TOC Elevation: *9.25 feet msl*
Completed at *1510 on 4-17-95*	Depth to Groundwater: *5.66 feet TOC* Measured: *6-21-95*
Drilling Method: *4.25" ID (7.5" OD) HSA with split spoon*	Groundwater Elevation: *3.59 feet msl*
Drilling Company: *Alliance Environmental*	Total Well Depth: *15 feet bgs*
Geologist: *John Hardy*	Well Screen: *2.5 to 12.5 feet bgs*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
0–15							SP	Surface Conditions: cement floor inside building. No split spoons were taken. Not able to put the derrick up. Lithology determined from cuttings.	
15									5.7
20									

WELL DIAGRAM



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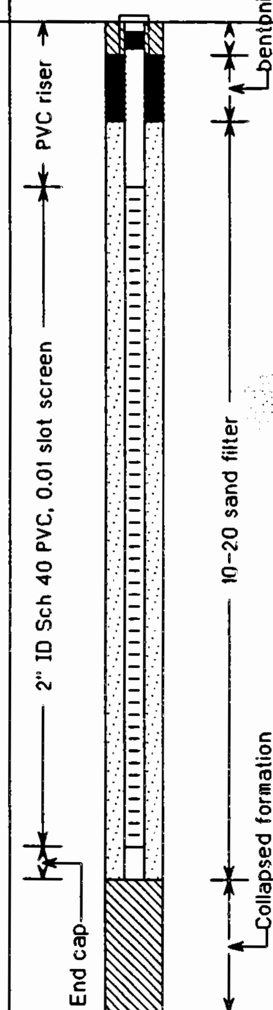
Monitoring Well NBCC047015

Project: *Zone C – Naval Base Charleston*	Coordinates: *2315491 E, 377355 N N*
Location: *Charleston, SC*	Surface Elevation: *9.1 feet msl*
Started at *1345 on 4-17-95*	TOC Elevation: *8.96 feet msl*
Completed at *1425 on 4-17-95*	Depth to Groundwater: *4.92 feet TOC* Measured: *6-21-95*
Drilling Method: *4.25" ID (7.5" OD) HSA with split spoon*	Groundwater Elevation: *4.04 feet msl*
Drilling Company: *Alliance Environmental*	Total Well Depth: *15 feet bgs*
Geologist: *John Hardy*	Well Screen: *2.5 to 12.5 feet bgs*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
0								Surface Conditions: cement floor inside of building.	
								No split spoons were taken. Not able to put the derrick up. Lithology determined from cuttings.	
5									
							SP		
10									
15									5.9
20									

WELL DIAGRAM



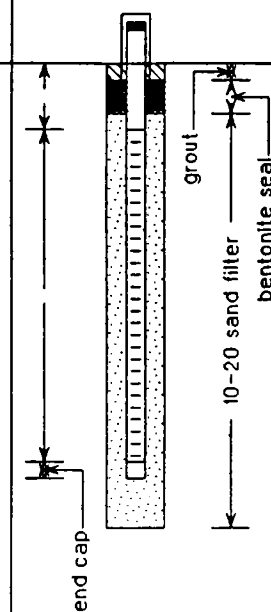
EnSafe/Allen & Hoshall

Monitoring Well NBCC044001

Project: *Zone C – Naval Base Charleston*	Coordinates: *2315032.83 E, 378836.55 N*
Location: *Charleston, SC*	Surface Elevation: *9.3 feet msl*
Started at *1020 on 3-29-95*	TOC Elevation: *11.70 feet msl*
Completed at *1110 on 3-29-95*	Depth to Groundwater: *4.92 feet TOC* Measured: *3-29-95*
Drilling Method: *4.25"ID (7.5" OD) HSA with split spoon*	Groundwater Elevation: *6.78 feet msl*
Drilling Company: *Alliance Environmental*	Total Well Depth: *12 feet bgs*
Geologist: *Peter Bayley*	Well Screen: *2 to 12 feet bgs*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
								Surface conditions: gravel and topsoil	
							SP	Sand: brown and orange, very fine to fine with trace of silt.	6.3 / 6
5			1	67	0		SW	Sand: light gray brown, very fine to medium, clean.	5
							SP	Sand: orange.	1.3 / .9
10			2	100	0		CH	Clay: dark brown, some silt, firm, plastic, wet.	.1
							SP	Sand: dark brown, very fine, trace silt, wet.	-.7
							CH	Clay: dark brown with black, some silt, soft to firm, plastic, wet.	-3.7 / -4.2
15			3	92	0		CL	Clay: blue green, silty, sandy, firm, plastic, wet with 1" dark brown very fine to fine sand, trace silt, wet.	-5.6

WELL DIAGRAM



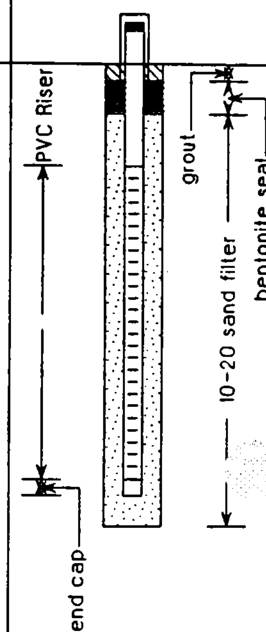
EnSafe/Allen & Hoshall

Monitoring Well NBCC044002

Project: *Zone C – Naval Base Charleston*	Coordinates: *2314759.35 E, 378759.94 N*
Location: *Charleston, SC*	Surface Elevation: *8.9 feet msl*
Started at *1305 on 3-29-95*	TOC Elevation: *11.20 feet msl*
Completed at *1335 on 3-29-95*	Depth to Groundwater: *7.23 feet TOC* Measured: *6-21-95*
Drilling Method: *4.25"ID (7.5" OD) HSA with split spoon*	Groundwater Elevation: *3.97 feet msl*
Drilling Company: *Alliance Environmental*	Total Well Depth: *13.1 feet bgs*
Geologist: *Peter Bayley*	Well Screen: *3.1 to 13.1 feet bgs*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
								Surface condition: soil	
5			1	67	0		SP	Sand: brown and orange, very fine to fine with trace of silt in faint laminae, bits of coal, soft, moist to wet.	5.9 / 4.6
10			2	67	0		SP	Sand: light brown with orange, very fine to fine, some silt, faint laminae, soft, wet.	.9 / .4
15			3	79	0		SP	Sand: orange-brown with faint gray laminae of blue-gray and brown, very fine to medium, soft, wet.	4.1 / 5.7
20									
25									
30									
35									
40									

WELL DIAGRAM



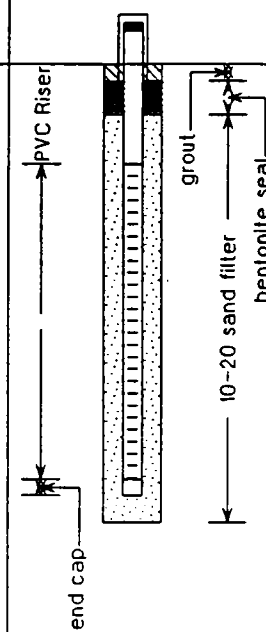
EnSafe/Allen & Hoshall

Monitoring Well NBCC044003

Project: *Zone C - Naval Base Charleston*	Coordinates: *2314692.29 E, 379112.06 N*
Location: *Charleston, SC*	Surface Elevation: *9.1 feet msl*
Started at *1440 on 3-29-95*	TOC Elevation: *11.14 feet msl*
Completed at *1500 on 3-29-95*	Depth to Groundwater: *7.23 feet TOC* Measured: *6-21-95*
Drilling Method: *4.25"ID (7.5" OD) HSA with split spoon*	Groundwater Elevation: *3.91 feet msl*
Drilling Company: *Alliance Environmental*	Total Well Depth: *13 feet bgs*
Geologist: *Peter Bayley*	Well Screen: *3 to 13 feet bgs*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
								Surface conditions: soil	
5			1	75	0		SP	Sand: brown grading to orange at 3.4', faint laminae (<5mm wide), very fine to fine, moist, some $CaCO_3$; bottom 0.5' consists of gray sand with black carbonaceous laminae 3mm thick, very fine, soft, wet.	6.1 4.6
10			2	54	0		SP	Sand: brown with dark brown/orange mottling, very fine to silty dry.	1.1 .9
							CH	Clay: blue-green with orange FeOx, some silt to very fine sand in basal 3".	0
15			3	75	0		CH SC	Clay: brown and red brown with gray at the base, some silt, grading into orangish-brown clay, some silt, small sand laminae, wet at 13.5'.	3.9 5.4
20									
25									
30									
35									
40									

WELL DIAGRAM



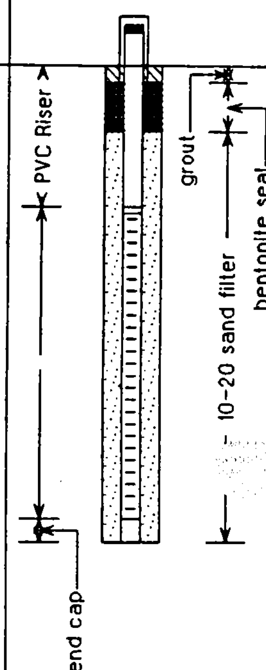
EnSafe/Allen & Hoshall

Monitoring Well NBCC044004

Project: *Zone C – Naval Base Charleston*	Coordinates: *2314818.67 E, 379208.12 N*
Location: *Charleston, SC*	Surface Elevation: *feet msl*
Started at *0930 on 3-30-95*	TOC Elevation: *10.95 feet msl*
Completed at *1020 on 3-30-95*	Depth to Groundwater: *7.11 feet TOC* Measured: *6-21-95*
Drilling Method: *4.25"ID (7.5" OD) HSA with split spoon*	Groundwater Elevation: *3.84 feet msl*
Drilling Company: *Alliance Environmental*	Total Well Depth: *14.4 feet bgs*
Geologist: *Peter Bayley*	Well Screen: *4.3 to 14.3 feet bgs*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
5			1	13	0		CL / CH	Clay: dark gray and light brown with some silt, moderately plastic, some coal.	
10			2	42	4.5		SC / CL / SM	Sand: orange and greenish-gray, faint laminae of very fine to fine sand, some silt, firm and plastic, moist to wet.	
								Sand: greenish-gray, very fine to fine, silty, trace of clay, wet.	
15			3	92	5.8		SC / CL / CH	Sand: brown, very fine to medium, some silt, wet, intermixed with brown to black, silty, plastic, clay, wet.	
			4	100	0		SP	Clay: bluish-gray with brown mottling, some silt, firm, plastic, wet; bottom 2" orangish-brown, very fine to fine, silty sand, soft, wet.	
20								Sand: orange-brown, very fine to medium.	
25									
30									
35									
40									

WELL DIAGRAM



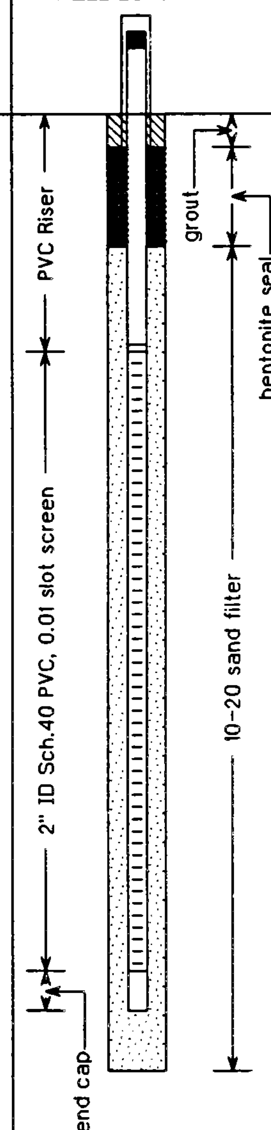
EnSafe/Allen & Hoshall

Monitoring Well NBCC044005

Project: *Zone C – Naval Base Charleston*	Coordinates: *2314896.01 E, 379513.24 N*
Location: *Charleston, SC*	Surface Elevation: *5.5 feet msl*
Started at *1100 on 3-30-95*	TOC Elevation: *7.77 feet msl*
Completed at *1250 on 3-30-95*	Depth to Groundwater: *4.38 feet TOC* Measured: *6-21-95*
Drilling Method: *4.25" ID (7.5" OD) HSA with split spoon*	Groundwater Elevation: *3.39 feet msl*
Drilling Company: *Alliance Environmental*	Total Well Depth: *14.5 feet bgs*
Geologist: *Peter Bayley*	Well Screen: *3.6 to 13.6 feet bgs*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
							SP SM SP	Sand: dark brown, very fine, some silt, damp to moist, coarsening to very fine to medium, gray, wet sand at 3.4'.	2.5 2.2 2
5			1	30	0				
								Extremely soft during drive--no recovery	
10			2	0	0		CL SC	Clay: dark brown, sandy, very soft, wet.	4.5 5
							SM SP	Sand: gray, very fine, silty, trace clay, wet.	5.2
			3	67	0		CH OH	Clay: dark brown-gray, some silt, trace very fine sand, firm, plastic , wet.	5.9
							CH OH	Clay: dark brownish-gray, some silt, firm, plastic H_2S odor, wet.	7.5
15			4	95	0		CH	Clay: dark brown, silty, trace very fine sand, soft, plastic, wet.	8.7 9.5
20									

WELL DIAGRAM



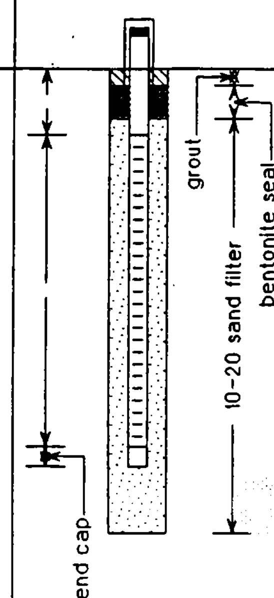
EnSafe/Allen & Hoshall

Monitoring Well NBCC044006

Project: *Zone C – Naval Base Charleston*	Coordinates: *2315069.37 E, 379513.24 N*
Location: *Charleston, SC*	Surface Elevation: *5.3 feet msl*
Started at *1405 on 3-30-95*	TOC Elevation: *7.75 feet msl*
Completed at *1600 on 3-30-95*	Depth to Groundwater: *2.78 feet TOC* Measured: *6-21-95*
Drilling Method: *4.25" ID (7.5" OD) HSA with split spoon*	Groundwater Elevation: *4.97 feet msl*
Drilling Company: *Alliance Environmental*	Total Well Depth: *12.0 feet bgs*
Geologist: *Peter Bayley*	Well Screen: *2 to 12 feet bgs*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
								Surface conditions: soil	
5			1	42	1.8		SM	2" *Sand*, orangish-brown and gray, very fine, silty, moist to wet. Sand: orange-brown to gray, very fine, silty, trace of clay, soft, wet	2.3 / 1.5
10			2	95	0		CH	Clay: dark gray with some black, some silt, soft, plastic, wet. *Aseptic odor*	2.7 / 3.7
							CH / OH	Clay: dark brown to black with some gray, some silt, soft, with wood fibers, wet; some very fine, silty, gray sand in top 1".	4.6 / 7.7
15			3	50	0		CH	Clay: as above, dark brown, soft, wet.	8.7
20									
25									
30									
35									
40									

WELL DIAGRAM



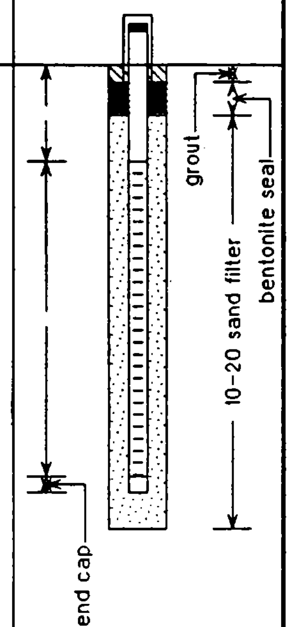
EnSafe/Allen & Hoshall

Monitoring Well NBCC044007

Project: *Zone C - Naval Base Charleston*	Coordinates: *2315155.45 E, 379700.24 N*
Location: *Charleston, SC*	Surface Elevation: *7.3 feet msl*
Started at *0945 on 4-3-955*	TOC Elevation: *9.74 feet msl*
Completed at *1055 on 4-3-955*	Depth to Groundwater: *8.02 feet TOC* Measured: *6-21-95*
Drilling Method: *4.25" ID (7.5" OD) HSA with split spoon*	Groundwater Elevation: *1.72 feet msl*
Drilling Company: *Alliance Environmental*	Total Well Depth: *12.9 feet bgs*
Geologist: *Peter Bayley*	Well Screen: *2.9 to 12.9 feet bgs*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
								Surface conditions: soil and grass	
							CH	Clay: olive-brown to dark brown with some tan mottling, some silt, soft, plastic, moist to wet.	4.3, 3.3
5			1	50	0				
10			2	0	0		CH	Clay: brown, with yellow-brown silty sandy pods, soft, plastic, wet.	2.7, 3.1
			3	58	0		SP	Sand: brown and gray, very fine to fine, trace silt, wet, soft, with 1 cm gray clay laminae in upper 2".	3.6, 3.9
							SM	Sand: dark brown, very fine, silty, wet, soft.	
							SP		5.7
							SM	Sand: gray-green, very fine, silty, some clay, soft, wet.	6.2
15			4	80	0		SP		7.3
							CH	Clay: gray green, some silt, some very fine sand, soft to firm, plastic, with yellow-brown sand pods at basal 2", wet.	
20									
25									
30									
35									
40									

WELL DIAGRAM



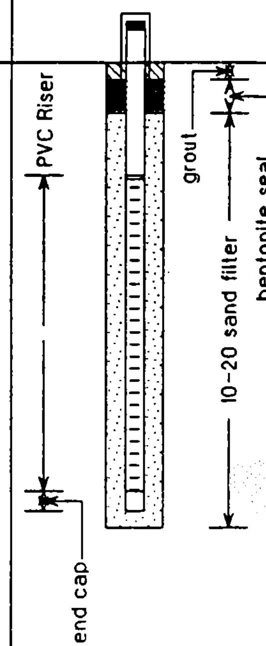
EnSafe/Allen & Hoshall

Monitoring Well NBCC044008

Project: *Zone C – Naval Base Charleston*	Coordinates: *2315102.05 E, 379164.75 N*
Location: *Charleston, SC*	Surface Elevation: *8.7 feet msl*
Started at *1400 on 4-3-95*	TOC Elevation: *11.13 feet msl*
Completed at *1500 on 4-3-95*	Depth to Groundwater: *6.03 feet TOC* Measured: *6-21-95*
Drilling Method: *4.25" ID (7.5" OD) HSA with split spoon*	Groundwater Elevation: *5.10 feet msl*
Drilling Company: *Alliance Environmental*	Total Well Depth: *13.5 feet bgs*
Geologist: *Peter Bayley*	Well Screen: *3.4 to 13.4 feet bgs*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
								Surface conditions: soil and gravel	
5			1	40	0		SP	Sand: gray, very fine to medium, with thinly interbedded fine to medium light gray sand, wet bottom 6".	5.7 4.9
10			2	100	0		CH	Clay: olive to gray brown, trace sand, fine black sand laminae, firm, plastic, wet.	.7 1.3
15			3	75	0		CH	Clay: olive-gray to gray brown, some black silt, firm, plastic, wet.	4.3 4.9
							SM	Sand: gray, very fine to fine, some silt, soft grading to more stiff and more sand, with <4 mm gray clayey silty laminae interbedded, wet.	5.8
20									
25									
30									
35									
40									

WELL DIAGRAM



EnSafe/Allen & Hoshall

Boring NBCC044027

Project: *Zone C – Naval Base Charleston*	Coordinates: *E, N*
Location: *Charleston, SC*	Geologist: *S. Weatherford*
Started at *1620 on 8-6-97*	Surface Elevation: *6.1 feet msl*
Completed at *1650 on 8-6-97*	Depth to Groundwater: *n/a feet TOC* Measured: *n/a*
Drilling Method: *Rotasonic (7.5" OD casing w/ 3.8" ID core bit)*	Groundwater Elevation: *n/a feet msl*
Drilling Company: *Alliance Environmental*	Total Depth: *45 feet bgs*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
								Surface conditions: grass-fill	
							Fill	fill: grey-tan-black; sandy; clayey.	
5			1	100	0		SP	Sand: tan; coarse; wet.	1.1
							OL/OH	Clay: black-blue-grey; soft; silty w/ organics; wet.	-.9
10							SP	Sand: tan-grey; medium grained-well sorted; wet.	-4.9
15			2	100	0		OL/OH	Clay: grey-black; silty; soft; w/ organics.	-8.9000
20							SM/SP	Sand: tan-grey; fine grained-well sorted; wet.	-13.9

EnSafe/Allen & Hoshall

Boring NBCC044027

Project: *Zone C – Naval Base Charleston*	Coordinates: *E, N*
Location: *Charleston, SC*	Geologist: *S. Weatherford*
Started at *1620 on 8-6-97*	Surface Elevation: *6.1 feet msl*
Completed at *1650 on 8-6-97*	Depth to Groundwater: *n/a feet TOC* Measured: *n/a*
Drilling Method: *Rotasonic (7.5" OD casing w/ 3.8" ID core bit)*	Groundwater Elevation: *n/a feet msl*
Drilling Company: *Alliance Environmental*	Total Depth: *45 feet bgs*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
			3	100	0		SM/SP	Sand: grey-black; fine; wet.	-20.9
28							OL/OH	Clay: blue-black; fine grained-silty; soft; damp w/ organics.	-27.9
33								tree	-28.4
			4	100	0		SP	Sand: grey; medium grained; wet.	-28.9
							SC	Sand/Clay: grey-green; loose; sandy/clay; clayey/sand w/ shell hash; wet.	-29.9
38							ML/CL	Clay: olive; silty; tight; dry; brittle; marl.	
43			5	100	0				-3.

EnSafe/Allen & Hoshall

Boring NBCC044028

Project: *Zone C - Naval Base Charleston*	Coordinates: *E, N*
Location: *Charleston, SC*	Geologist: *S. Weatherford*
Started at *1730 on 8-6-97*	Surface Elevation: *5.9 feet msl*
Completed at *1810 on 8-6-97*	Depth to Groundwater: *n/a feet TOC* Measured: *n/a*
Drilling Method: *Rotasonic (7.5" OD casing w/ 3.8" ID core bit)*	Groundwater Elevation: *n/a feet msl*
Drilling Company: *Alliance Environmental*	Total Depth: *45 feet bgs*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
								Surface conditions: grass; fill.	
							Fill	fill: grey-tan-brown; sandy; silty; clayey.	
5			1	100	0		SM	Sand: tan-grey; fine grained to silty; loose; wet.	.9
							OL/OH	Clay: black-green; fine grained to silty; damp.	-.1
10							SC/SM	Sand: fine grained; silty; clayey; wet.	-4.1
							OL	Clay: dark brown; silty to fine grained; w/ organics.	-5.1
							SC	Sand: grey-green; clayey.	-8.1
15			2	100	0		CL/OL	Clay: grey; silty; soft.	-9.1
							CL/SC	Clay: red-grey-green mottled; coarse; stiff; sandy.	-10.1
							SM	Sand: grey-red-tan; well sorted; wet.	-11.1
20									
							SC/CL	Sand: w/ interbedded clay.	-15.1
							SM	Sand: grey; silty to fine grained; wet.	-16.1

EnSafe/Allen & Hoshall	Boring NBCC044028
Project: *Zone C – Naval Base Charleston*	Coordinates: *E, N*
Location: *Charleston, SC*	Geologist: *S. Weatherford*
Started at *1730 on 8-6-97*	Surface Elevation: *5.9 feet msl*
Completed at *1810 on 8-6-97*	Depth to Groundwater: *n/a feet TOC* Measured: *n/a*
Drilling Method: *Rotasonic (7.5" OD casing w/ 3.8" ID core bit)*	Groundwater Elevation: *n/a feet msl*
Drilling Company: *Alliance Environmental*	Total Depth: *45 feet bgs*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
			3	100	0		SM		-19.1
28							SC	Sand: grey-green; loose; clayey; mottled; wet.	-24.1
							OL/SC	Clay: olive green; silty-sandy.	-26.1
33			4	100	0		SP	Sand: white-grey; coarse; lime; wet. 2" black banding at 33' & 34'. 35 to 37 feet: phosphate nodules and shell hash.	-31.1
38							CL	Clay: green-blue; stiff; damp; w/ fine grained sand stringers.	-37.1
43			5	100	0		ML/CL	Clay: olive-brown; fine sand to silty; inorganic; dry; marl.	-3[illegible]

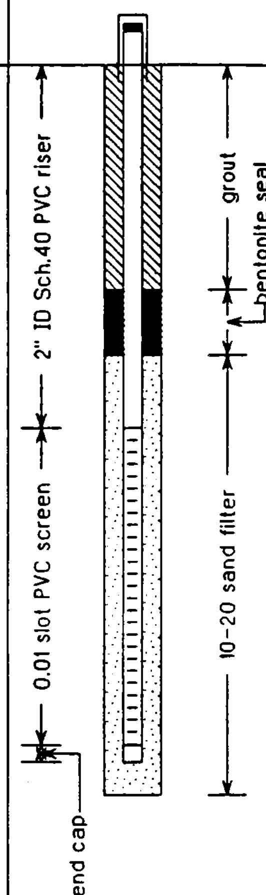
EnSafe/Allen & Hoshall

Monitoring Well NBCC510001

Project: *Zone C – Naval Base Charleston*	Coordinates: *2313655.36 E, 377529.9988 N N*
Location: *Charleston, SC*	Surface Elevation: *27.0 feet msl*
Started at *1500 on 4-4-95*	TOC Elevation: *29.16 feet msl*
Completed at *1625 on 4-4-95*	Depth to Groundwater: *17.82 feet TOC* Measured: *6-21-95*
Drilling Method: *4.25" ID (7.5" OD) HSA with split spoon*	Groundwater Elevation: *11.34 feet msl*
Drilling Company: *Alliance Environmental*	Total Well Depth: *21 feet bgs*
Geologist: *Peter Bayley*	Well Screen: *11 to 21 feet bgs*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
								Surface conditions: soil and grass	
5			1	71	0		SP	Sand: brown to orange-brown, very fine to fine, dry to damp.	24 / 22.7
10			2	71	0		SP	Sand: buff to white to brown, very fine to fine, damp to moist.	19 / 17.7
15			3	83	0		SP	Sand: as above with very thin orange-brown laminae in basal 3", damp to moist, grading to dark brown, very fine sand, trace of silt, soft, wet.	14 / 12.3
20			4	58	0		SP	Sand: brown, very fine to fine, trace of silt, soft, wet.	9 / 7.8 / 7
			5	100	0		SP	Sand: brown to dark brown, very fine to medium, wet.	5
25									
30									
35									
40									

WELL DIAGRAM



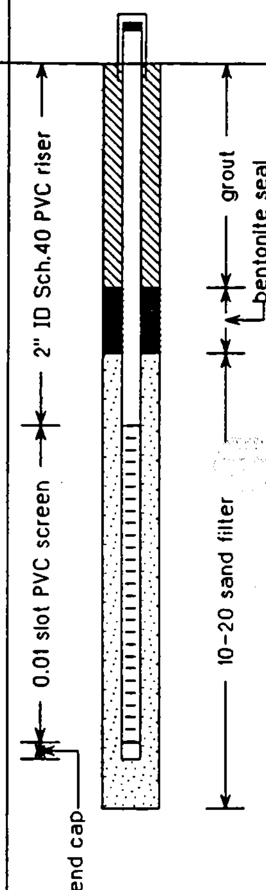
EnSafe/Allen & Hoshall

Monitoring Well NBCC510002

Project: *Zone C – Naval Base Charleston*	Coordinates: *2313652.72 E, 377552.84 N*
Location: *Charleston, SC*	Surface Elevation: *26.3 feet msl*
Started at *0825 on 4-5-95*	TOC Elevation: *28.30 feet msl*
Completed at *0925 on 4-5-95*	Depth to Groundwater: *17.27 feet TOC* Measured: *6-21-95*
Drilling Method: *4.25" ID (7.5" OD) HSA with split spoon*	Groundwater Elevation: *11.03 feet msl*
Drilling Company: *Alliance Environmental*	Total Well Depth: *21 feet bgs*
Geologist: *Peter Bayley*	Well Screen: *11 to 21 feet bgs*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
								Surface conditions:	
5			1	71	0		SP	Sand: orange-brown, very fine to fine, trace of silt, dark very thin laminae, dry to damp.	23.3 / 21.9
10			2	50	0		SP	Sand: brown to dark brown, very fine to fine, trace of silt, with 1" buff to white very fine to fine/medium sand, damp to moist.	18.3 / 17.3
15			3	75	0		SP/SM	Sand: red-brown to dark brown, very fine, some silt, soft, moist to wet.	13.3 / 11.8
20			4	75	0		SP/SM	Sand: dark brown to brown, very fine to fine, some silt, soft, wet.	8.3 / 6.8
25									
30									
35									
40									

WELL DIAGRAM



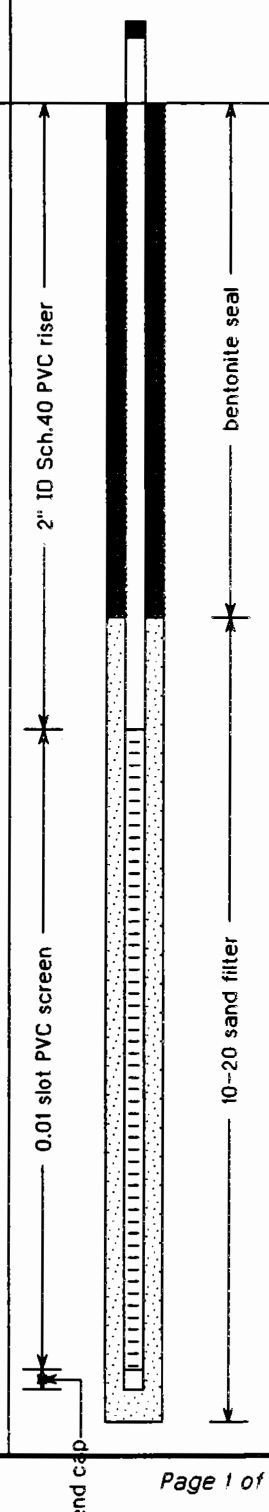
EnSafe/Allen & Hoshall

Monitoring Well NBCC508003

Project: *Zone C – Naval Base Charleston*	Coordinates: *2313775.98 E, 377332.99 N*
Location: *Charleston, SC*	Surface Elevation: *26.88 feet msl*
Started at *0900 on 8-7-97*	TOC Elevation: *29.44 feet msl*
Completed at *1115 on 8-7-97*	Depth to Groundwater: *13.78 feet TOC* Measured: *8-8-97*
Drilling Method: *4.25" ID (7.5" OD) HSA with split spoon*	Groundwater Elevation: *15.66 feet msl*
Drilling Company: *Alliance Environmental*	Total Well Depth: *20 feet bgs*
Geologist: *Q. Macdonald*	Well Screen: *9.5 to 19.5 feet bgs*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
0								Surface conditions: grass, soil and fill.	
3								Not logged: shelby tube pushed, 100% recovery.	
5								Sand: tan-brown-grey; fine grained to silty; damp.	21.9
			1	100	2.2				
			2	100	1.4			Sand: brown; fine grained to silty; damp.	
10									
			3	100	2.7			Sand: brown; silty; wet.	
							SM		
			4	100	2.2			Sand: brown; silty; stiff; wet.	
15			5	100	2.9			Sand: grey-black, fine grained to silty; wet.	
			6	100	2.8			Sand: tan-brown; silty; loose; wet.	
			7	100	1.4				7.9
20									

WELL DIAGRAM



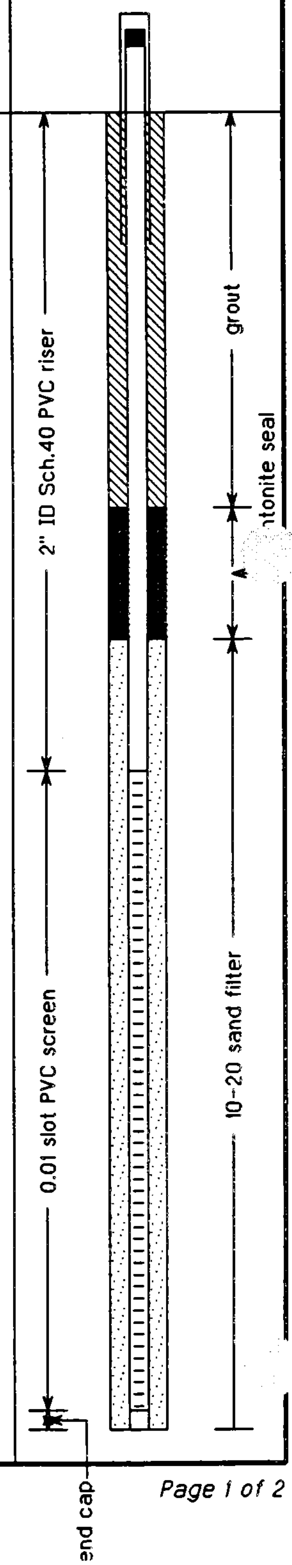
EnSafe/Allen & Hoshall

Monitoring Well NBCC511002

Project: *Zone C – Naval Base Charleston*	Coordinates: *2314828.86 E, 377125.08 N*
Location: *Charleston, SC*	Surface Elevation: *26.59 feet msl*
Started at *1330 on 8-6-97*	TOC Elevation: *29.09 feet msl*
Completed at *1700 on 8-6-97*	Depth to Groundwater: *12.34 feet TOC* Measured: *8-8-97*
Drilling Method: *4.25" ID (7.5" OD) HSA with split spoon*	Groundwater Elevation: *16.75 feet msl*
Drilling Company: *Alliance Environmental*	Total Well Depth: *20 feet bgs*
Geologist: *S. Weatherford*	Well Screen: *10 to 20 feet bgs*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
								Surface conditions: soil and grass	
								Sand: brown-tan; loose; loamy sand and soil. logged from cuttings.	
								Not logged: shelby tube pushed, 100% recovery.	
5							SM/ML	Sand: brown to dark brown; fine grained to silty; damp.	21.6
			1	50	0			Sand: dark brown to orange brown; fine grained to silty; damp.	
			2	80	0			No recovery	17.6
10									
			3	0	0			Sand: tan to brown; fine grained; wet.	15.6
			4	70	13			Sand: tan to brown-grey; fine grained to silty; wet; w/ heavy diesel oder and black staining.	
15			5	50	229		SM	Sand: grey, fine grained to silty; wet; heavy diesel oder.	
			6	80	20			Sand: grey; fine grained to silty; wet; w/ black staining.	
			7	75	64			Sand: tan; silty.	
20							SM/SC		6.6

WELL DIAGRAM



EnSafe/Allen & Hoshall	Monitoring Well NBCC511002
Project: Zone C – Naval Base Charleston	Coordinates: 2314828.86 E, 377125.08 N
Location: Charleston, SC	Surface Elevation: 26.59 feet msl
Started at 1330 on 8-6-97	TOC Elevation: 29.09 feet msl
Completed at 1700 on 8-6-97	Depth to Groundwater: 12.34 feet TOC Measured: 8-8-97
Drilling Method: 4.25" ID (7.5" OD) HSA with split spoon	Groundwater Elevation: 16.75 feet msl
Drilling Company: Alliance Environmental	Total Well Depth: 20 feet bgs
Geologist: S. Weatherford	Well Screen: 10 to 20 feet bgs

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)	WELL DIAGRAM
			8	100	2.0		SM/SC	Sand: tan-brown; fine grained; clayey.	6.6 / 5.6	
25										
30										
35										
40										

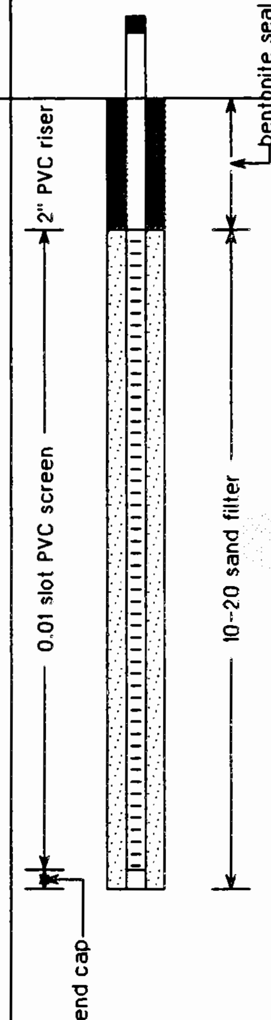
EnSafe/Allen & Hoshall

Monitoring Well NBCC512002

Project: *Zone C – Naval Base Charleston*	Coordinates: *2314623.25 E, 378046.37 N*
Location: *Charleston, SC*	Surface Elevation: *7.85 feet msl*
Started at *1400 on 8-7-97*	TOC Elevation: *10.23 feet msl*
Completed at *1552 on 8-7-97*	Depth to Groundwater: *3.83 feet TOC* Measured: *8-8-97*
Drilling Method: *4.25" ID (7.5" OD) HSA with split spoon*	Groundwater Elevation: *6.40 feet msl*
Drilling Company: *Alliance Environmental*	Total Well Depth: *12 feet bgs*
Geologist: *S. Weatherford*	Well Screen: *2 to 12 feet bgs*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
								Surface conditions: grass, soil and fill.	
								Not logged: shelby tube pushed, 100% recovery.	
5								Clay: blue-green; silty; soft; damp; w/ organics-roots; marsh-clay.	2.8
			1	50	450		OL OH	Clay: blue-grey; silty; soft; damp; organic marsh-clay.	
			2	10	208			Clay: grey-green; silty; soft; wet; organic marsh-clay.	
10									
			3	10	220				-3.2
15									
20									

WELL DIAGRAM



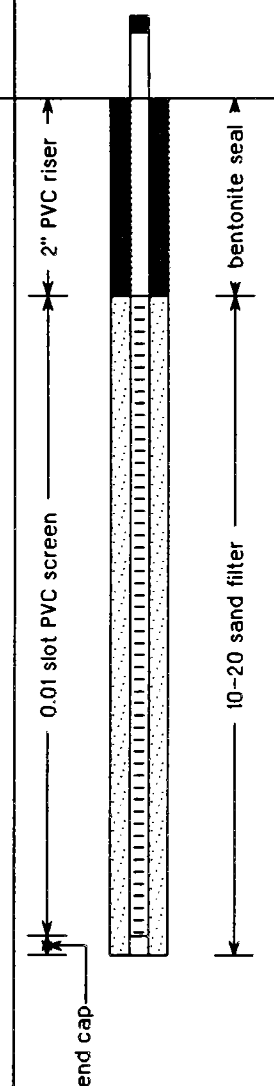
EnSafe/Allen & Hoshall

Monitoring Well NBCC512003

Project: *Zone C - Naval Base Charleston*	Coordinates: *2314655.44 E, 378020.93 N*
Location: *Charleston, SC*	Surface Elevation: *10.00 feet msl*
Started at *1620 on 8-7-97*	TOC Elevation: *12.38 feet msl*
Completed at *1750 on 8-7-97*	Depth to Groundwater: *5.21 feet TOC* Measured: *8-8-97*
Drilling Method: *4.25" ID (7.5" OD) HSA with split spoon*	Groundwater Elevation: *7.17 feet msl*
Drilling Company: *Alliance Environmental*	Total Well Depth: *13 feet bgs*
Geologist: *S. Weatherford*	Well Screen: *3 to 13 feet bgs*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
								Surface conditions: grass, soil and fill.	
								Not logged: shelby tube pushed, 50% recovery.	
5								Not logged, 0% recovery.	5
			1	0	0		OL/OH	Clay: blue-green; fine-silty; soft; damp; marsh-clay.	
			2	75	58				
10									
			3	10	21		SM/SP	Sand: grey; fine grained; wet.	1
			4	70	0				-3
15									
20									

WELL DIAGRAM



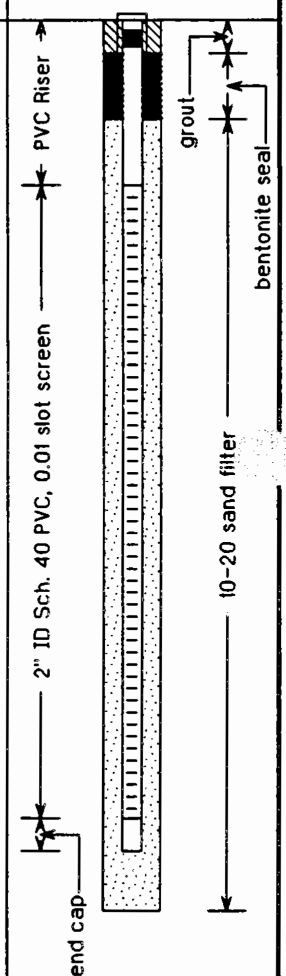
EnSafe/Allen & Hoshall

Monitoring Well NBCC523001

Project: *Zone C – Naval Base Charleston*	Coordinates: *2315701.02 E, 376195.11 N*
Location: *Charleston, SC*	Surface Elevation: *8.3 feet msl*
Started at *0830 on 4-4-95*	TOC Elevation: *7.89 feet msl*
Completed at *0935 on 4-4-95*	Depth to Groundwater: *4.63 feet TOC* Measured: *6-21-95*
Drilling Method: *4.25" ID (7.5" OD) HSA with split spoon*	Groundwater Elevation: *3.26 feet msl*
Drilling Company: *Alliance Environmental*	Total Well Depth: *12.6 feet bgs*
Geologist: *Peter Bayley*	Well Screen: *2.5 to 12.5 feet bgs*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
								Surface conditions: Asphalt	
							SP SM	Sand: brown, very fine to fine, some silt, soft, wet.	5.3 / 4.1
5			1	63	0				
							SP SM	Sand: grayish-brown, very silty, wet, grading to orange-brown with gray laminae, very fine, some silt, wet at 8.3'.	.3 / .4
10			2	38	0				
							SP SM	Sand: orange, very fine to medium, trace of silt, wet, soft; grades orange-gray, very fine to fine, silty, trace clay at 13.3'; grades to orange-brown, silty and wet at 13.8'; coarsens to very fine to medium at 14.3'.	4.7 / 6.5
15			3	92	0				6.7
							SP	Sand: brown, very fine to fine.	
			4	100	0				8.7
20									

WELL DIAGRAM



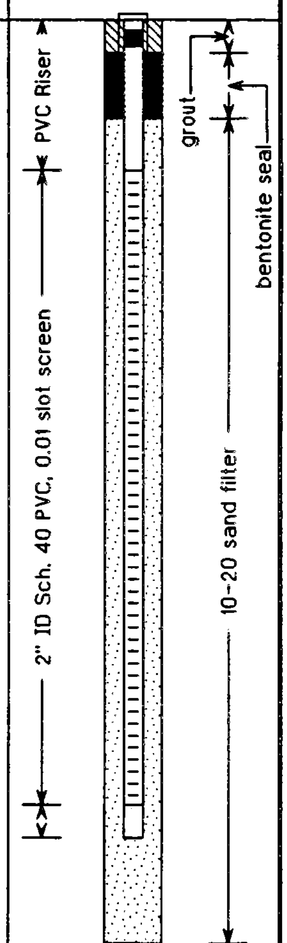
EnSafe/Allen & Hoshall

Monitoring Well NBCC523002

Project: *Zone C – Naval Base Charleston*	Coordinates: *2315577.21 E, 379122.78 N*
Location: *Charleston, SC*	Surface Elevation: *9.5 feet msl*
Started at *1015 on 4-4-95*	TOC Elevation: *9.10 feet msl*
Completed at *1120 on 4-4-95*	Depth to Groundwater: *5.40 feet TOC* Measured: *6-21-95*
Drilling Method: *4.25" ID (7.5" OD) HSA with split spoon*	Groundwater Elevation: *3.70 feet msl*
Drilling Company: *Alliance Environmental*	Total Well Depth: *12.4 feet bgs*
Geologist: *Peter Bayley*	Well Screen: *2.4 to 12.4 feet bgs*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
								Surface conditions: Asphalt	
							SP	Sand: light brown, very fine to fine, damp.	6.5 / 5.8
5			1	33	0				
							SP	Sand: gray with trace of irregular Fe-Ox stain, very fine to fine, trace of silt, soft, wet, grading orange, very fine to medium sand with a trace of silt, soft, wet.	1.5 / .3
10			2	58	0				
							SP / SW	Sand: brown, very fine to fine, wet; last 1" consists of black gravel, < 1cm angular chunks, possibly asphalt.	3.5 / 4.5
15			3	50	0				
20									

WELL DIAGRAM



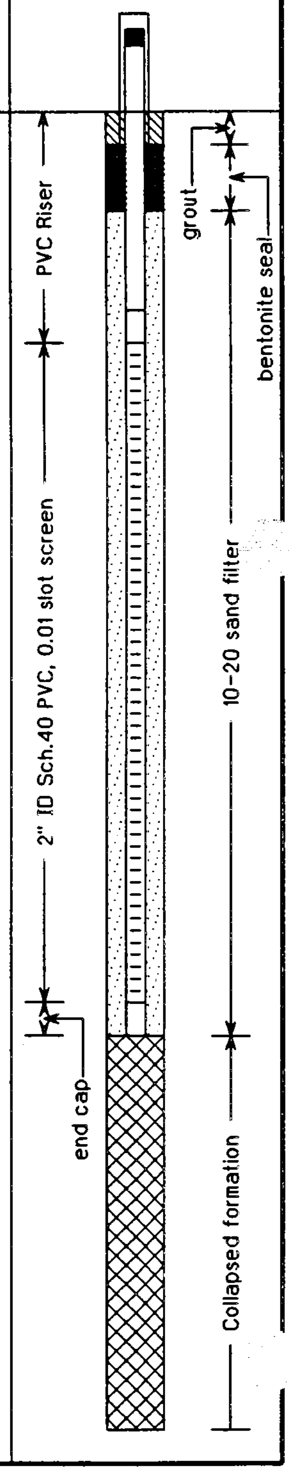
EnSafe/Allen & Hoshall

Monitoring Well NBCCGDC001

Project: *Zone C – Naval Base Charleston*	Coordinates: *2314318.79 E, 375850.70 N*
Location: *Charleston, SC*	Surface Elevation: *25.4 feet msl*
Started at *0840 on 3-28-95*	TOC Elevation: *27.69 feet msl*
Completed at *1300 on 3-28-95*	Depth to Groundwater: *12.05 feet TOC* Measured: *6-21-95*
Drilling Method: *4.25"ID (7.5" OD) HSA with split spoon*	Groundwater Elevation: *15.64 feet msl*
Drilling Company: *Alliance Environmental*	Total Well Depth: *14 feet bgs*
Geologist: *Peter Bayley*	Well Screen: *3.5 to 13.5 feet bgs*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
								Surface conditions: soil and gravel	
								Auger cuttings 0 to 3': Silt: dark brown, clayey.	
									22.4
							SP	Sand: orangish-brown, very fine, soft, loose, grading to buff, fine to very fine to medium, sand, soft, loose.	
									21
5			1	70	0.4				
									17.4
							SP	Sand: buff and brown to orangish-brown, very fine, wet.	
									15.8
10			2	75	0.1				
									12.4
							SP	Sand: dark brown, very fine with a trace of silt, wet, soft. Grades into buff to light orange-brown fine to medium grained sand, wet, soft.	
									10.8
15			3	80	0				
									7.4
							SP	Sand: dark gray, very fine to fine, silty, wet.	
									6.9
							CL	Clay: olive gray, very silty, wet, very soft, with shell hash.	
20			4	100	0				5.4

WELL DIAGRAM



EnSafe/Allen & Hoshall

Monitoring Well NBCCGDC001

Project: Zone C – Naval Base Charleston	Coordinates: 2314318.79 E, 375850.70 N
Location: Charleston, SC	Surface Elevation: 25.4 feet msl
Started at 0840 on 3-28-95	TOC Elevation: 27.69 feet msl
Completed at 1300 on 3-28-95	Depth to Groundwater: 12.05 feet TOC Measured: 6-21-95
Drilling Method: 4.25"ID (7.5" OD) HSA with split spoon	Groundwater Elevation: 15.64 feet msl
Drilling Company: Alliance Environmental	Total Well Depth: 14 feet bgs
Geologist: Peter Bayley	Well Screen: 3.5 to 13.5 feet bgs

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
									5.4
							CL	Clay: dark gray, some silt, wet, firm, plastic.	2.4
25			5	100	0		SM	Sand: gray, very fine to medium, some silt, fine clay laminae.	.9 / .4
							SM	Sand: gray, very fine with silt, wet, soft, shell hash. Bottom 8" contained substantial shell hash, small black PO_4 nodules.	2.6
30			6	95	0				4.5
							SM	Sand: yellow, very fine, clean, wet, soft, with 2" gray shell hash at 33.2'.	7.6
35			7	100	0				9.6
							SP / SM	Sand: gray, very fine with trace of silt, some shell fragments wet, firm.	12.6
									14
40			8	70	0				

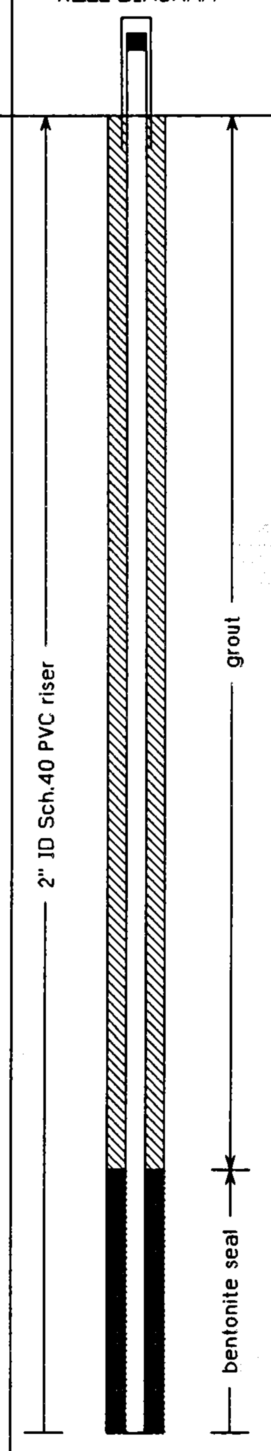
WELL DIAGRAM

Collapsed formation

EnSafe/Allen & Hoshall	Monitoring Well NBCCGDC01D
Project: *Zone C – Naval Base Charleston*	Coordinates: *2314327.99 E, 375843.72 N*
Location: *Charleston, SC*	Surface Elevation: *24.8 feet msl*
Started at *1300 on 4-4-95*	TOC Elevation: *26.98 feet msl*
Completed at *1600 on 4-4-95*	Depth to Groundwater: *12.66 feet TOC* Measured: *6-21-95*
Drilling Method: *Rotasonic (7.5" OD casing, 3.8" ID coring bit)*	Groundwater Elevation: *14.32 feet msl*
Drilling Company: *Alliance Environmental*	Total Well Depth: *36 feet bgs*
Geologist: *Britton Dotson*	Well Screen: *26 to 36 feet bgs*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
0							SP	Surface conditions: grass Sand: gray to dark brown; fine; well-sorted; saturated; 1" of topsoil at top of sample.	
5									
10									
15			1	20	0		SC	Clay-sand: green-gray, increasing sand content at 25', with some shell beds.	9.8
20									

WELL DIAGRAM



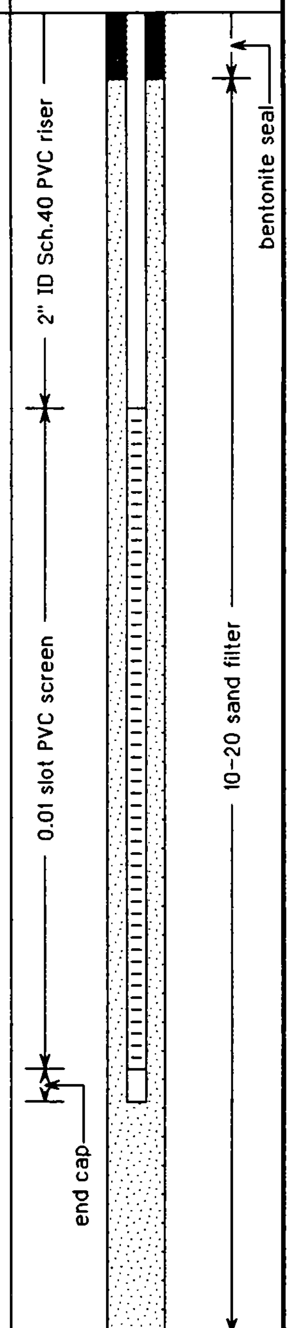
EnSafe/Allen & Hoshall

Monitoring Well NBCCGDC01D

Project: *Zone C – Naval Base Charleston*	Coordinates: *2314327.99 E, 375843.72 N*
Location: *Charleston, SC*	Surface Elevation: *24.8 feet msl*
Started at *1300 on 4-4-95*	TOC Elevation: *26.98 feet msl*
Completed at *1600 on 4-4-95*	Depth to Groundwater: *12.66 feet TOC* Measured: *6-21-95*
Drilling Method: *Rotasonic (7.5" OD casing, 3.8" ID coring bit)*	Groundwater Elevation: *14.32 feet msl*
Drilling Company: *Alliance Environmental*	Total Well Depth: *36 feet bgs*
Geologist: *Britton Dotson*	Well Screen: *26 to 36 feet bgs*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
25							SC	shell hash	
									-1.2
							SW	Sand: med. to coarse grained; well-sorted; high shell hash content .	
									-4.2
30							SP	Sand: light gray to white; fine grained; crumbly and saturated.	
35			2	100	0				
									-11.2
							ML/CL	Clay: mustard yellow; sandy upper portion; Marl.	
40									

WELL DIAGRAM



EnSafe/Allen & Hoshall

Monitoring Well NBCCGDC01D

Project: *Zone C – Naval Base Charleston*	Coordinates: *2314327.99 E, 375843.72 N*
Location: *Charleston, SC*	Surface Elevation: *24.8 feet msl*
Started at *1300 on 4-4-95*	TOC Elevation: *26.98 feet msl*
Completed at *1600 on 4-4-95*	Depth to Groundwater: *12.66 feet TOC* Measured: *6-21-95*
Drilling Method: *Rotasonic (7.5" OD casing, 3.8" ID coring bit)*	Groundwater Elevation: *14.32 feet msl*
Drilling Company: *Alliance Environmental*	Total Well Depth: *36 feet bgs*
Geologist: *Britton Dotson*	Well Screen: *26 to 36 feet bgs*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)	WELL DIAGRAM
45										
							ML/CL			backfill
50										
55			3	100	0				30.2	
60										

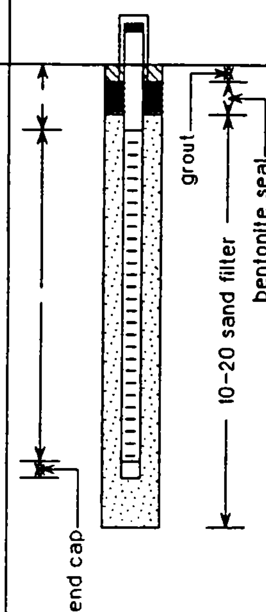
EnSafe/Allen & Hoshall

Monitoring Well NBCCGDC002

Project: *Zone C – Naval Base Charleston*	Coordinates: *2315519.50 E, 378294.58 N*
Location: *Charleston, SC*	Surface Elevation: *9.0 feet msl*
Started at *0750 on 3-29-95*	TOC Elevation: *11.45 feet msl*
Completed at *0925 on 3-29-95*	Depth to Groundwater: *7.29 feet TOC* Measured: *6-21-95*
Drilling Method: *4.25"ID (7.5" OD) HSA with split spoon*	Groundwater Elevation: *4.16 feet msl*
Drilling Company: *Alliance Environmental*	Total Well Depth: *14 feet bgs*
Geologist: *Peter Bayley*	Well Screen: *2 to 12 feet bgs*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
								Surface conditions: soil and gravel	
								Auger cuttings 0 to 3'--Sand: brown, very fine, clean.	6
5			1	5	0		CH	Sand: as above, grading into olive-brown clay, silty, soft to firm plastic, wet.	5.5
							CH	Clay: black (oil stain)	1 / .5
10			2	100	0		SP	Sand: light brown, very fine, trace silt, wet.	-1
							SP	Sand: brown, very fine to some silt, very soft, wet.	-4 / -4.3
15			3	95	0		CH	Clay: brown with some yellow-brown near 13.6', grading into green- gray clay, some silt, firm, plastic, very thin sand laminae with increasing sand towards base, wet.	-5.9
20									
25									
30									
35									
40									

WELL DIAGRAM



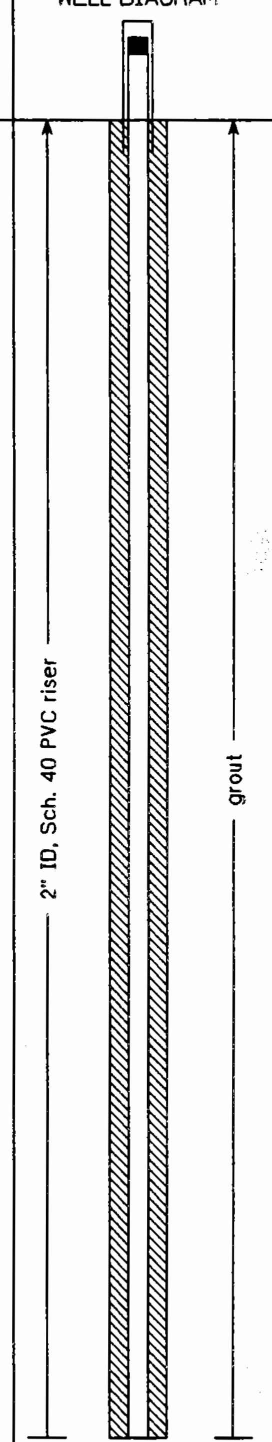
EnSafe/Allen & Hoshall

Monitoring Well NBCCGDC02D

Project: *Zone C – Naval Base Charleston*	Coordinates: *2315526.89 E, 378298.23 N*
Location: *Charleston, SC*	Surface Elevation: *9.3 feet msl*
Started at *0800 on 4-5-95*	TOC Elevation: *11.17 feet msl*
Completed at *1350 on 4-5-95*	Depth to Groundwater: *7.84 feet TOC* Measured: *6-21-95*
Drilling Method: *Rotasonic (7.5" OD casing, 3.8" ID coring bit)*	Groundwater Elevation: *3.33 feet msl*
Drilling Company: *Alliance Environmental*	Total Well Depth: *71 feet bgs*
Geologist: *Britton Dotson*	Well Screen: *61 to 71 feet bgs*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
							FILL	Fill: gravel, wood, topsoil, grass.	
							SP	Sand: dark brown to black, fine to medium.	7.3
5							SP/SC	Sand: tan to gray, fine to medium, with increasing clay content toward the base.	5.3
10							CL/CH	Clay: gray, stiff, little sand.	1.3
							SP	Sand: gray, fine to medium, little clay.	-2.7
15			1	100	0		SP	Sand: gray, fine to medium.	
20									

WELL DIAGRAM



EnSafe/Allen & Hoshall	Monitoring Well NBCCGDC02D
Project: *Zone C – Naval Base Charleston*	Coordinates: *2315526.89 E, 378298.23 N*
Location: *Charleston, SC*	Surface Elevation: *9.3 feet msl*
Started at *0800 on 4-5-95*	TOC Elevation: *11.17 feet msl*
Completed at *1350 on 4-5-95*	Depth to Groundwater: *7.84 feet TOC* Measured: *6-21-95*
Drilling Method: *Rotasonic (7.5" OD casing, 3.8" ID coring bit)*	Groundwater Elevation: *3.33 feet msl*
Drilling Company: *Alliance Environmental*	Total Well Depth: *71 feet bgs*
Geologist: *Britton Dotson*	Well Screen: *61 to 71 feet bgs*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
25									
30							SP		
35			2	100	0			Sand: orange-brown, medium.	
40									

WELL DIAGRAM

2" ID, Sch. 40 PVC riser

grout

EnSafe/Allen & Hoshall	Monitoring Well NBCCGDC02D
Project: *Zone C - Naval Base Charleston*	Coordinates: *2315526.89 E, 378298.23 N*
Location: *Charleston, SC*	Surface Elevation: *9.3 feet msl*
Started at *0800 on 4-5-95*	TOC Elevation: *11.17 feet msl*
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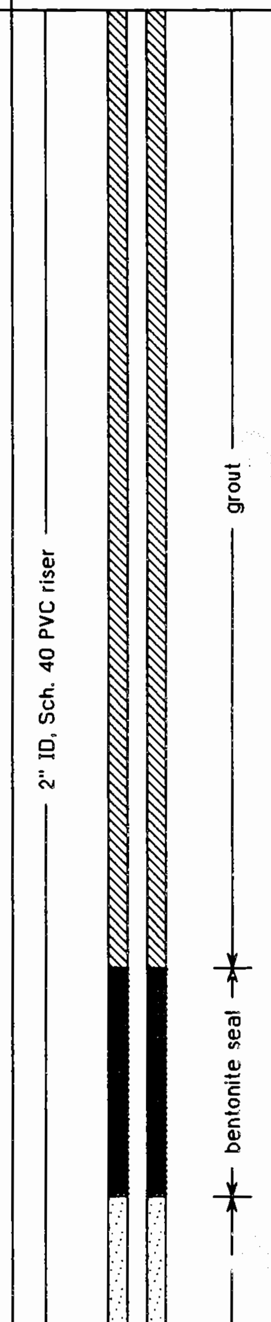
Geologist: *Britton Dotson*	Well Screen: *61 to 71 feet bgs*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
							SP	Sand: gray, medium.	
45									
								Sand: brown to dark brown, medium.	
								Sand: dark gray, shelly, medium.	
							CL	Clay: gray.	-39.7
50							SP	Sand: dark gray, shelly, medium.	-40.7
							CL/CH	Clay: stiff, brittle, silty with shells at base.	-44.7
55			3	100	0				
							SM/SC	Sand: dark gray, fine, silty, clayey.	-47.7
60									

WELL DIAGRAM



EnSafe/Allen & Hoshall

Monitoring Well NBCCGDC02D

Project: *Zone C – Naval Base Charleston*	Coordinates: *2315526.89 E, 378298.23 N*
Location: *Charleston, SC*	Surface Elevation: *9.3 feet msl*
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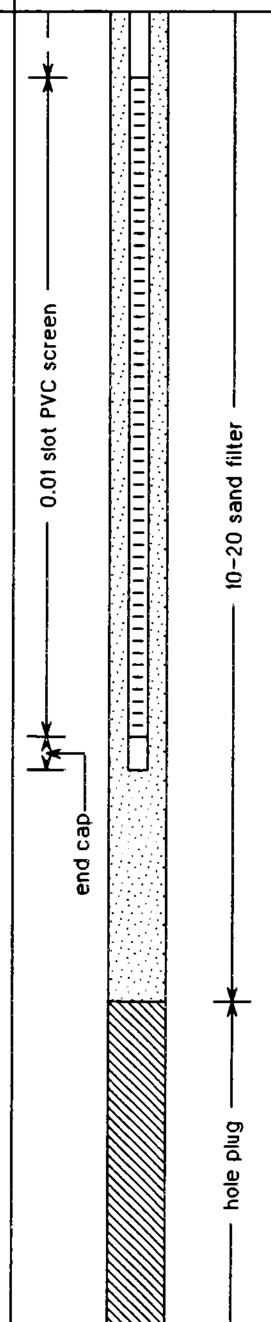
Completed at *1350 on 4-5-95*	Depth to Groundwater: *7.84 feet TOC* Measured: *6-21-95*
Drilling Method: *Rotasonic (7.5" OD casing, 3.8" ID coring bit)*	Groundwater Elevation: *3.33 feet msl*
Drilling Company: *Alliance Environmental*	Total Well Depth: *71 feet bgs*
Geologist: *Britton Dotson*	Well Screen: *61 to 71 feet bgs*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
65							SM/SC		
70			4	100	0			Clay: olive-brown, marl.	60.7
75							ML/CL		
80									

WELL DIAGRAM



EnSafe/Allen & Hoshall

Monitoring Well NBCCGDC02D

Project: *Zone C – Naval Base Charleston*	Coordinates: *2315526.89 E, 378298.23 N*
Location: *Charleston, SC*	Surface Elevation: *9.3 feet msl*
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Drilling Method: *Rotasonic (7.5" OD casing, 3.8" ID coring bit)*	Groundwater Elevation: *3.33 feet msl*
Drilling Company: *Alliance Environmental*	Total Well Depth: *71 feet bgs*
Geologist: *Britton Dotson*	Well Screen: *61 to 71 feet bgs*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)	WELL DIAGRAM
							ML/CL			hole plug
85			5	100	0				75.7	
90										
95										
100										

Appendix B

Zone C

Geotechnical/Physical Parameter Data Reports

SCI
Construction Materials
Non Destructive
Geotechnical
Environmental

SOIL CONSULTANTS, INC.
ENGINEERS & GEOLOGISTS
Since 1951

P.O. Drawer 698 • Charleston, South Carolina 29402 • 803/723-4539 • Fax 803/723-3648

April 26, 1995

Ensafe
400 Technecenter Dr., Suite 301
Milford, Ohio 45150

Attention: Ms. Ginny L. Gray

SCI 95-636

Reference: Naval Base Charleston, S.C.
Zone I RFI Investigation (INCLUDES ZONE C DATA)
SOUTHNAVFACENGCOM Contract No.
N62467-89-D-0318-0063

Dear Ms. Gray:

Enclosed please find test results for analyses requested on the above referenced project.

Samples were delivered by your firm on April 6 and 19, 1995.

A total of 25 shelby tubes and 4 bag samples were tested for Moisture Content, Specific Gravity, and Hydrometer Sieve analyses. The shelby tube samples were also tested for bulk density, Porosity, and Hydraulic Conductivity/Permeability. Visual Description and Unit Weight of shelby tube samples were also conducted, as requested.

The Hydraulic Conductivity/Permeability, Moisture Content, Specific Gravity, Porosity and Bulk Density test results are listed in tabular form on a high density 3.5 inch computer disk, using Word Perfect Version 6.0.

The Hydrometer/Sieve Analyses are in graphic form, the shelby tube descriptions with related data are submitted on data sheets.

All test results are in hard copy, in triplicate. Only tabular data is recorded on the high desnity 3.5 inch computer disk.

All tests were conducted in accordance with ASTM specifications, per our fee proposal dated March 28, 1995.

Cutting of the shelby tubes was required on several of the samples in order to test. Based on this condition along with tubes having bent ends, we were directed to dispose of the tubes, by your firm, as they were not suitable for re-use.

If you have any questions, please call our office.

We thank you for the opportunity to be of service to you on this project and look forward to working with you again in the future.

Sincerely,

SOIL CONSULTANTS, INC.

Suzanne M Stroh

Suzanne M. Stroh
Environmental Manager

SMS/ab

Enclosures

cc: Ensafe
935 Houston Northcut Blvd.
Suite 113
Mt. Pleasant, S.C. 29464
Attn: Mr. Charlie Vernoy

CERTIFICATION OF COMPLETION (PROFESSIONAL SERVICES)

INSTRUCTIONS:

1. When all the requirements of the Subcontract or Statement of Work have been satisfied, the Subcontractor will submit the following certification to the on-site representative for approval.

2. Should the Subcontractor request partial or incremental payments, the certificate must indicate the performance completed to date and the basis of the claim for partial or incremental payments.

3. The completed certificate when signed by the E/A&H Site Manager or Task Order Manager must be forwarded to the Procurement Buyer who signed the original Purchase Order.

4. The written certification of completion shall be dated and the certifying official identified by name and title shall be duly authorized to bind the Seller by the Certification.

CERTIFICATE OF COMPLETION (PROFESSIONAL SERVICES)

The Seller named in Subcontract/Purchase Order Number 0349/95
and known as (Name of Firm) SOIL CONSULTANTS, INC.

hereby certifies that, to the best of their knowledge and belief, has completed all services as described and/or modified under Subcontract/Purchase Order Number ________________, and has complied with all the technical requirements of the Statement of Work.

DATED: 4-26-95

SIGNED BY: Suzanne M Stroh

TYPED/PRINTED NAME AND
TITLE OF CERTIFYING OFFICIAL:

EnSafe/Allen & Hoshall
Task Order/ Site Manager Approval: ________________

Typed/Printed Name and Title: SUZANNE M. STROH
ENVIRONMENTAL MANAGER

Date: APRIL 26, 1995

MATERIALS TESTING REPORT	SOIL CONSULTANTS, INC.	UNDISTURBED SAMPLE CHARACTERISTICS

PROJECT and STATE NAVAL BASE CHARLESTON, S.C. ZONE I RFI INVESTIGATION SOUTHNAVFACENGCOM CONTRACT NO. N62467-89-D-0318-0063

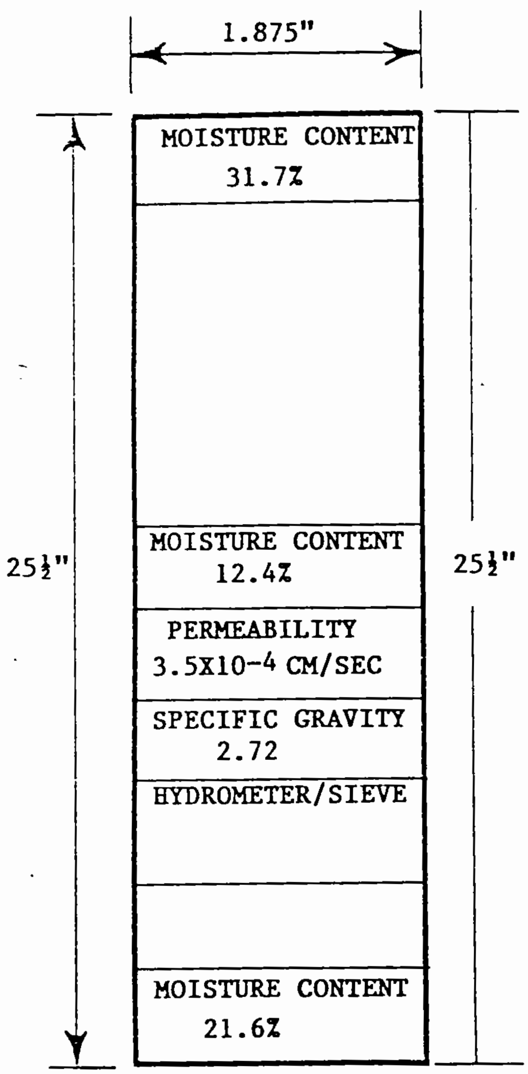
TESTED AT	APPROVED BY	DATE
SCI, CHARLESTON, S.C.		4-25-95

FIELD SAMPLE NO.	DEPTH (ft) from	DEPTH (ft) to	SAMPLE LOCATION	TYPE OF SAMPLE	LABORATORY NO
	14.5'	16.5'	NBCC-044-004	PUSHED	95-636

COLOR	RELATIVE MOISTURE	CONSISTENCY	POROSITY OR STRUCTURE	TEXTURE	POCKET PENETROMETER (TSF)	VISUAL CLASSIFICATION (USCS)
TAN	MOIST	SEMISOLID	UNIFORM	SAND		SM-SP

ω	21.9% %	γ_d	1.62 g/cc

REMARKS



TAN FINE SAND.

MATERIALS TESTING REPORT	SOIL CONSULTANTS, INC.	UNDISTURBED SAMPLE CHARACTERISTICS

PROJECT and STATE NAVAL BASE CHARLESTON, S.C. ZONE I RFI INVESTIGATION SOUTHNAVFACENGCOM CONTRACT NO. N62467-89-D-0318-0063

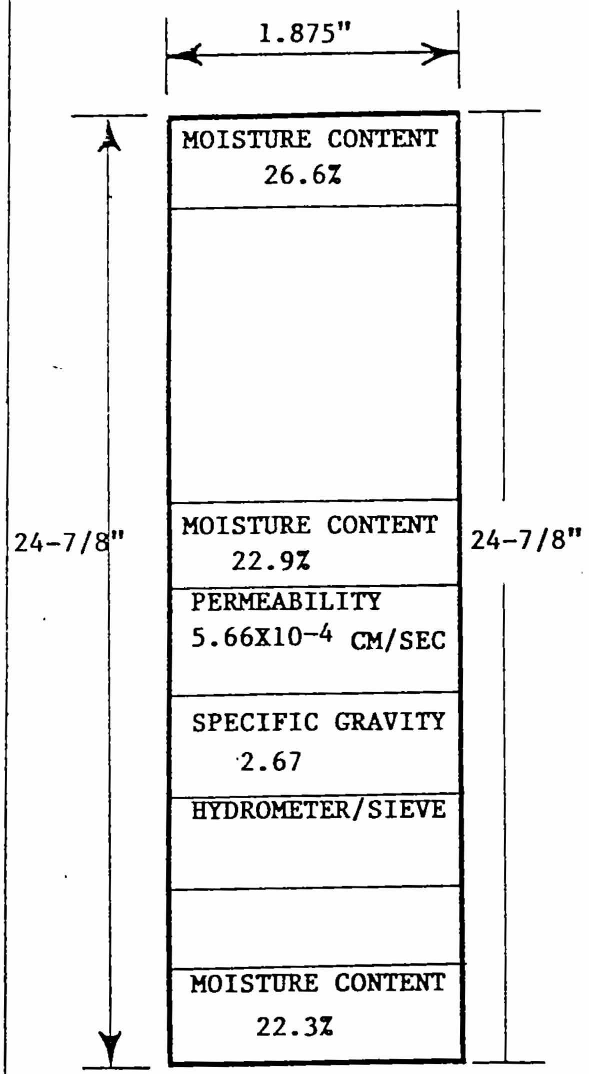
TESTED AT	APPROVED BY	DATE
SCI, CHARLESTON, S.C.	Suzanne McStool	4-25-95

FIELD SAMPLE NO.	DEPTH (ft) from	DEPTH (ft) to	SAMPLE LOCATION	TYPE OF SAMPLE	LABORATORY NO
	15'	17'	NBCC-047-005	PUSHED	95-636

COLOR	RELATIVE MOISTURE	CONSISTENCY	POROSITY OR STRUCTURE	TEXTURE	POCKET PENETROMETER (TSF)	VISUAL CLASSIFICATION (USCS)
LIGHT GRAY	MOIST	SEMISOLID	UNIFORM	SAND		SP

ω	23.9 %	γ_d	1.58 g/cc

REMARKS



LIGHT GRAY FINE SAND.

MATERIALS TESTING REPORT	SOIL CONSULTANTS, INC.	UNDISTURBED SAMPLE CHARACTERISTICS

PROJECT and STATE NAVAL BASE CHARLESTON, S.C. ZONE I RFI INVESTIGATION SOUTHNAVFACENGCOM CONTRACT NO. N62467-89-D-0318-0063

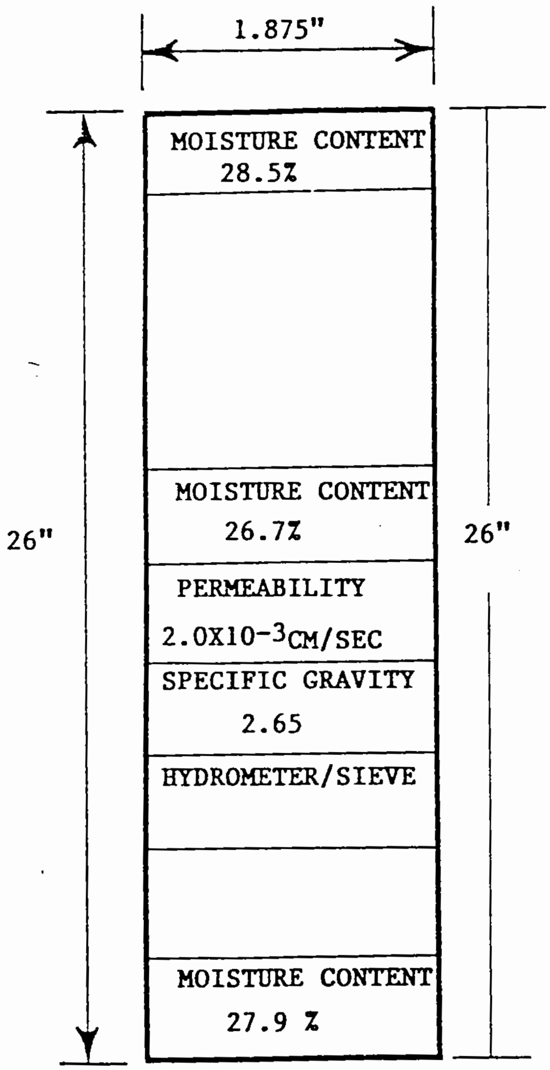
TESTED AT	APPROVED BY	DATE
SCI, CHARLESTON, S.C.	Signed	4-25-95

FIELD SAMPLE NO.	DEPTH (ft) from	DEPTH (ft) to	SAMPLE LOCATION	TYPE OF SAMPLE	LABORATORY NO
	NOT GIVEN		NBCC-510-001	PUSHED	95-636

COLOR	RELATIVE MOISTURE	CONSISTENCY	POROSITY OR STRUCTURE	TEXTURE	POCKET PENETROMETER (TSF)	VISUAL CLASSIFICATION (USCS)
TAN	MOIST	SEMISOLID	UNIFORM	SAND		SP

ω	27.7 %	γ_d	1.43 g/cc

REMARKS



TAN FINE SAND.

MATERIALS TESTING REPORT	SOIL CONSULTANTS, INC.	UNDISTURBED SAMPLE CHARACTERISTICS

PROJECT and STATE NAVAL BASE CHARLESTON, S.C. ZONE I RFI INVESTIGATION SOUTHNAVFACENGCOM CONTRACT NO. N62467-89-D-0318-0063

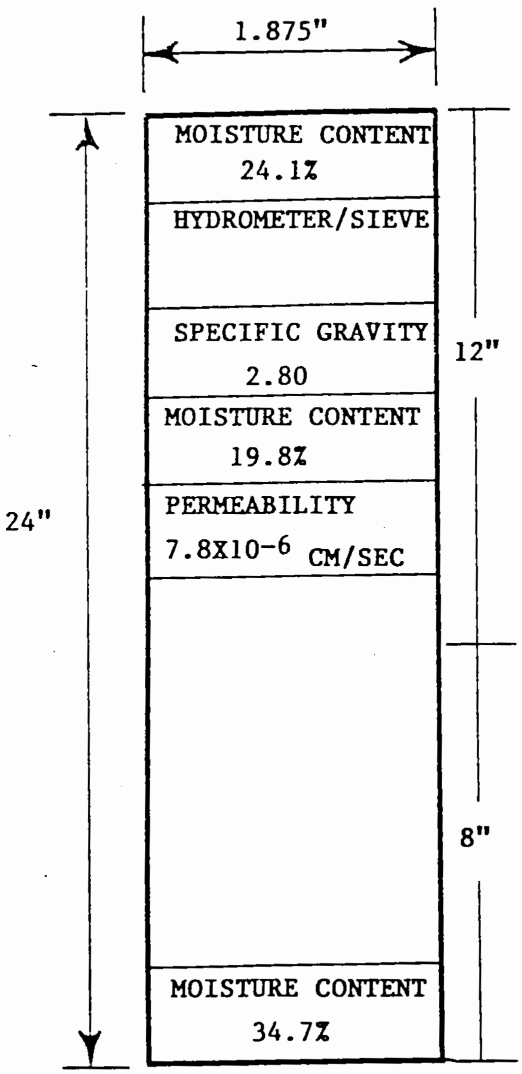
TESTED AT	APPROVED BY	DATE
SCI, CHARLESTON, S.C.	Jeanne M. Strot	4-25-95

FIELD SAMPLE NO.	DEPTH (ft) from	DEPTH (ft) to	SAMPLE LOCATION	TYPE OF SAMPLE	LABORATORY NO
	15'	17'	NBCC/523-001	PUSHED	95-636

COLOR	RELATIVE MOISTURE	CONSISTENCY	POROSITY OR STRUCTURE	TEXTURE	POCKET PENETROMETER (TSF)	VISUAL CLASSIFICATION (USCS)
TAN	MOIST	SEMISOLID	BANDED	SAND		SP

ω	26.2 %	γ_d	1.73 g/cc

REMARKS



TAN FINE SAND WITH INORGANIC CLAY LENSES & SLIGHT AGGREGATE CONTENT.

WHITISH TAN FINE SAND WITH FLBC(BASE COURSE MATERIAL).

Soil Consultants, Inc.

FOUNDATION & TESTING ENGINEERS

RESULTS OF PERMEABILITY OF GRANULAR SOILS
UNDISTURBED SHELBY TUBE SAMPLES

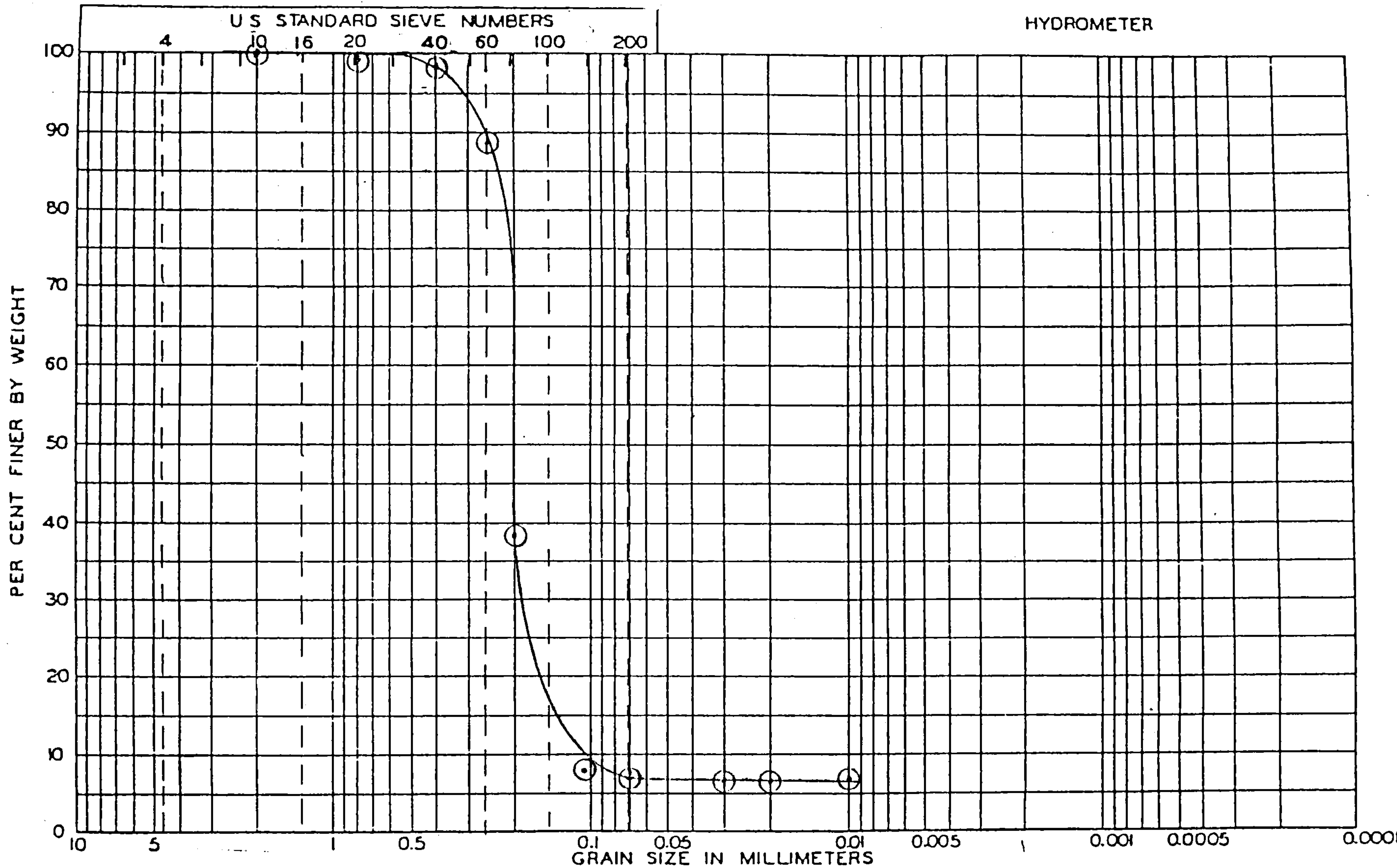
SAMPLE IDENTIFICATION	NBCC/ 044-004	NBCC/ 047-005	NBCC/ 510-001	NBCC/ 523-001
Sample length, cm	5.715	5.715	5.715	6.35
Sample Diameter,cm	16.63794	16.63794	16.637694	16.637694
Moisture Content, %	12.4	22.9	26.7	19.8
Unit Wet Weight, pcf	2.16	2.12	2.10	2.03
Unit Dry Weight, pcf	1.92	1.72	1.66	1.69
Sp. Gravity	2.72	2.67	2.65	2.80
Porosity (computed)	29.3	35.2	37.5	39.5
Permeability cm/sec	3.5X10-4 CM/SEC	5.66X10-4 CM/SEC	2.0X10-3 CM/SEC	7.8X10-6 CM/SEC
Visual Classification	SM-SP	SP	SP	SP

SAMPLE DEPTH: 14.5'-16.5' 15'-17' NOT GIVEN 15'-17'

PROJECT: NAVAL BASE CHARLESTON, S.C., ZONE I RFI INVESTIGATION
SOUTHNAVFACENGCOM CONTRACT NO. N62467-89-D-0318-0063

SCI REPORT NO. 95-636

DATE: 4-26-95



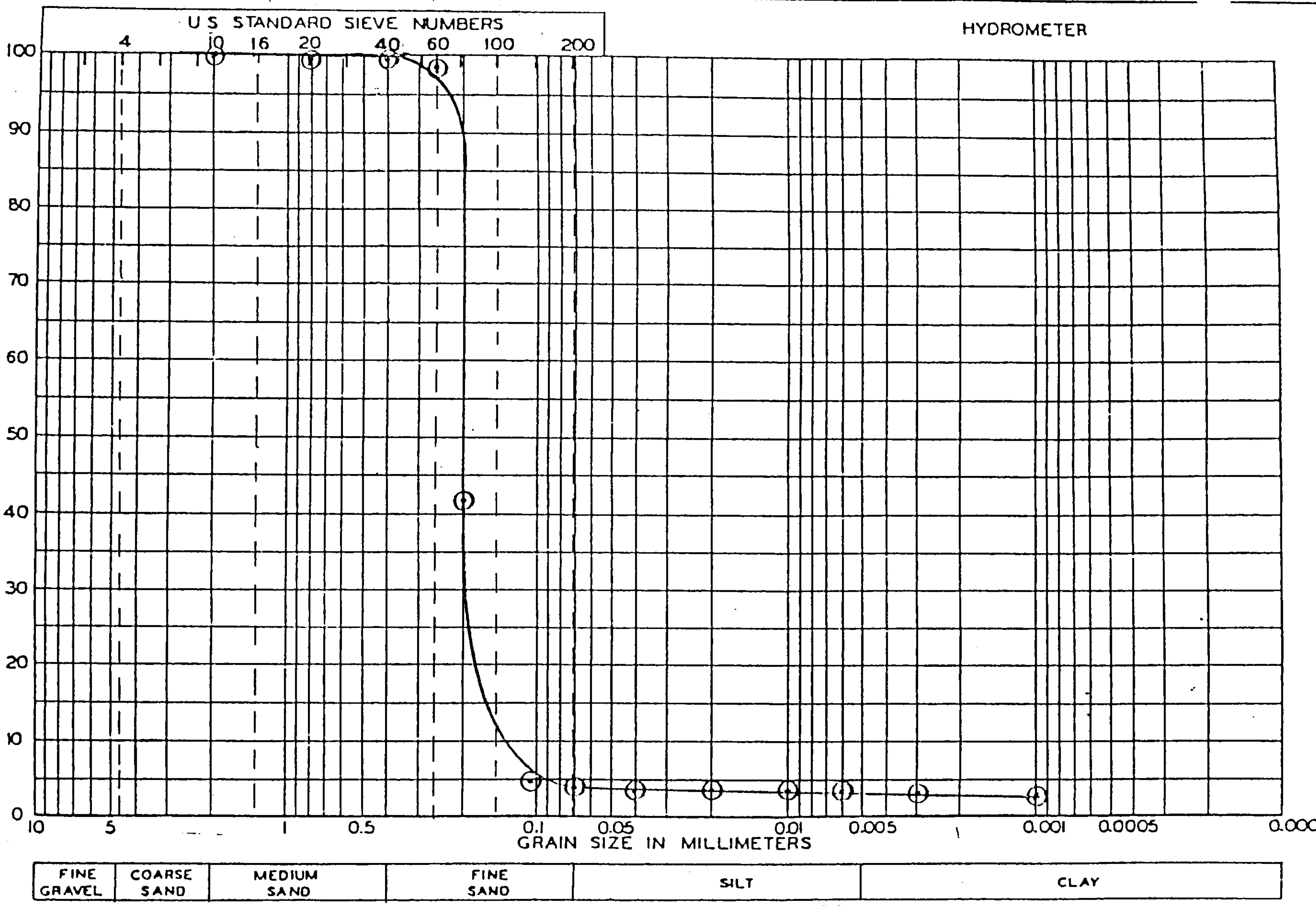
FINE GRAVEL	COARSE SAND	MEDIUM SAND	FINE SAND	SILT	CLAY

UNIFIED SOIL CLASSIFICATION SYSTEM

PROJECT NAVAL BASE CHARLESTON, S.C., ZONE I RFI INVESTIGATION
SOUTHNAVFACENGCOM CONTRACT NO. N62467-89-D-0318-0063
BORING NO ________ SAMPLE NO. NBCC-044-004

DEPTH 14.5-16.5' ELEVATION ______ REMARKS ______

GRAIN SIZE DISTRIBUTION DIAGRAM



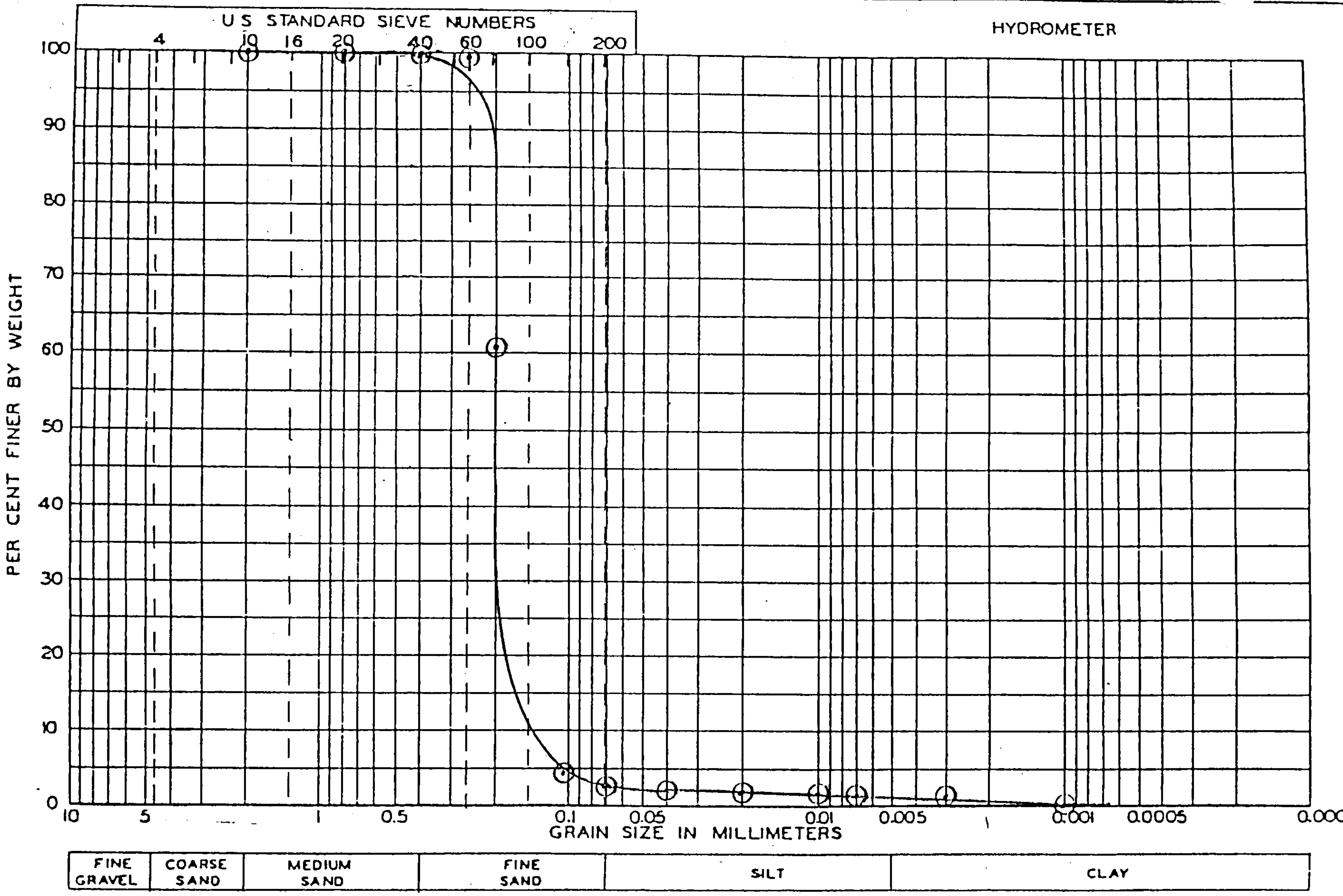
UNIFIED SOIL CLASSIFICATION SYSTEM

PROJECT NAVAL BASE CHARLESTON, S.C., ZONE I RFI INVESTIGATION BORING NO ________ SAMPLE NO. NBCC-047-005

SOUTHNAVFACENGCOM CONTRACT NO. N62467-89-D-0318-0063

DEPTH 15'-17' ELEVATION ______ REMARKS ______

GRAIN SIZE DISTRIBUTION DIAGRAM

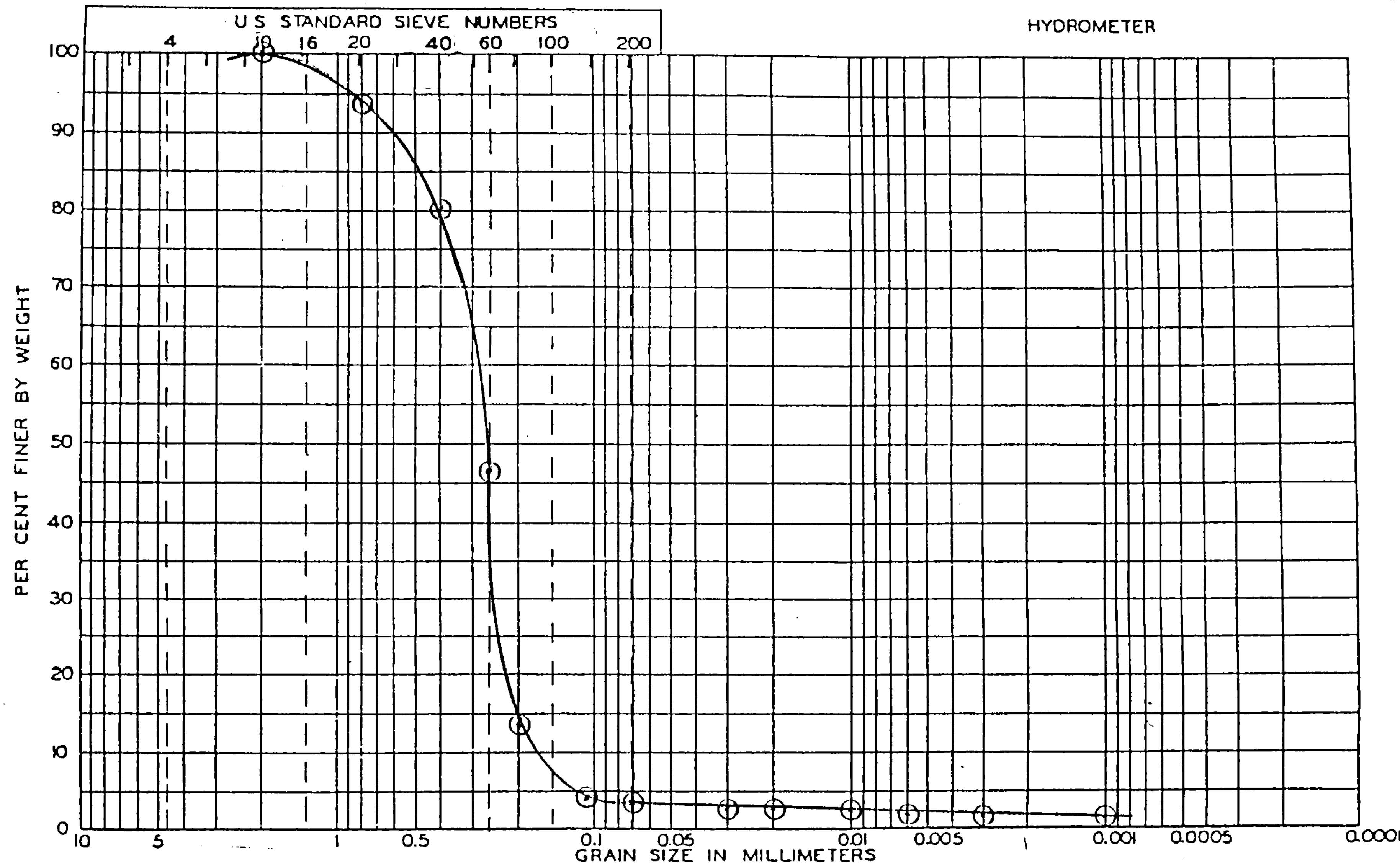


UNIFIED SOIL CLASSIFICATION SYSTEM

PROJECT NAVAL BASE CHARLESTON, S.C., ZONE I RFI INVESTIGATION SOUTHNAVFACENGCOM CONTRACT NO. N62467-89-D-0318-0063 BORING NO ________ SAMPLE NO. NBCC-510-001

DEPTH NOT GIVEN ELEVATION ______ REMARKS ______

GRAIN SIZE DISTRIBUTION DIAGRAM



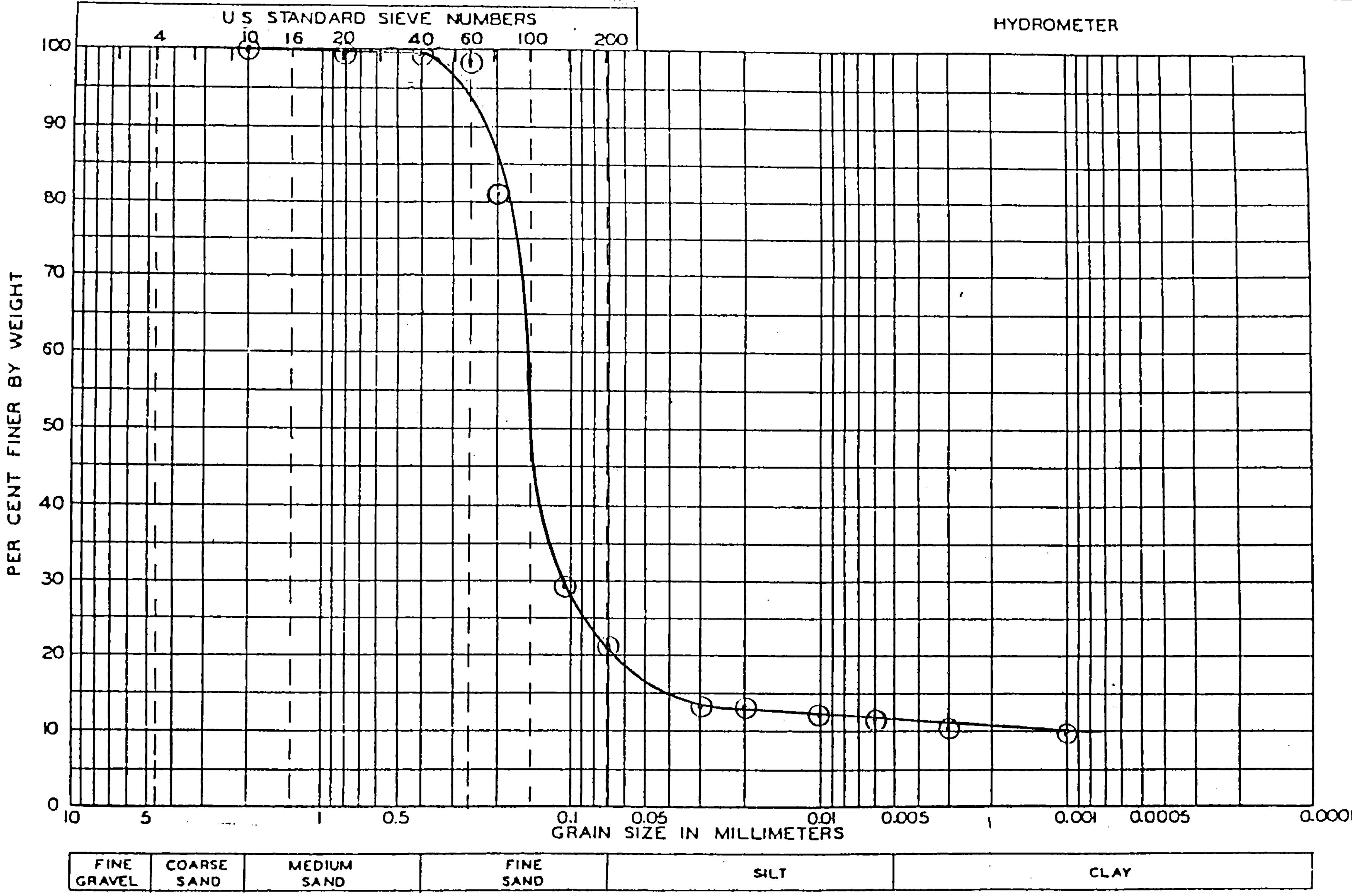
FINE GRAVEL	COARSE SAND	MEDIUM SAND	FINE SAND	SILT	CLAY

UNIFIED SOIL CLASSIFICATION SYSTEM

PROJECT NAVAL BASE CHARLESTON, S.C., ZONE I RFI INVESTIGATION SOUTHNAVFACENGCOM CONTRACT NO. N62467-89-D-0318-0063 BORING NO ______ SAMPLE NO. NBCC-523-001

DEPTH 15'-17' ELEVATION ______ REMARKS ______

GRAIN SIZE DISTRIBUTION DIAGRAM



UNIFIED SOIL CLASSIFICATION SYSTEM

PROJECT NAVAL BASE CHARLESTON, S.C., ZONE I RFI INVESTIGATION
SOUTHNAVFACENGCOM CONTRACT NO. N62467-89-D-0318-0063

BORING NO ________ SAMPLE NO. NBCC-GRD-02D

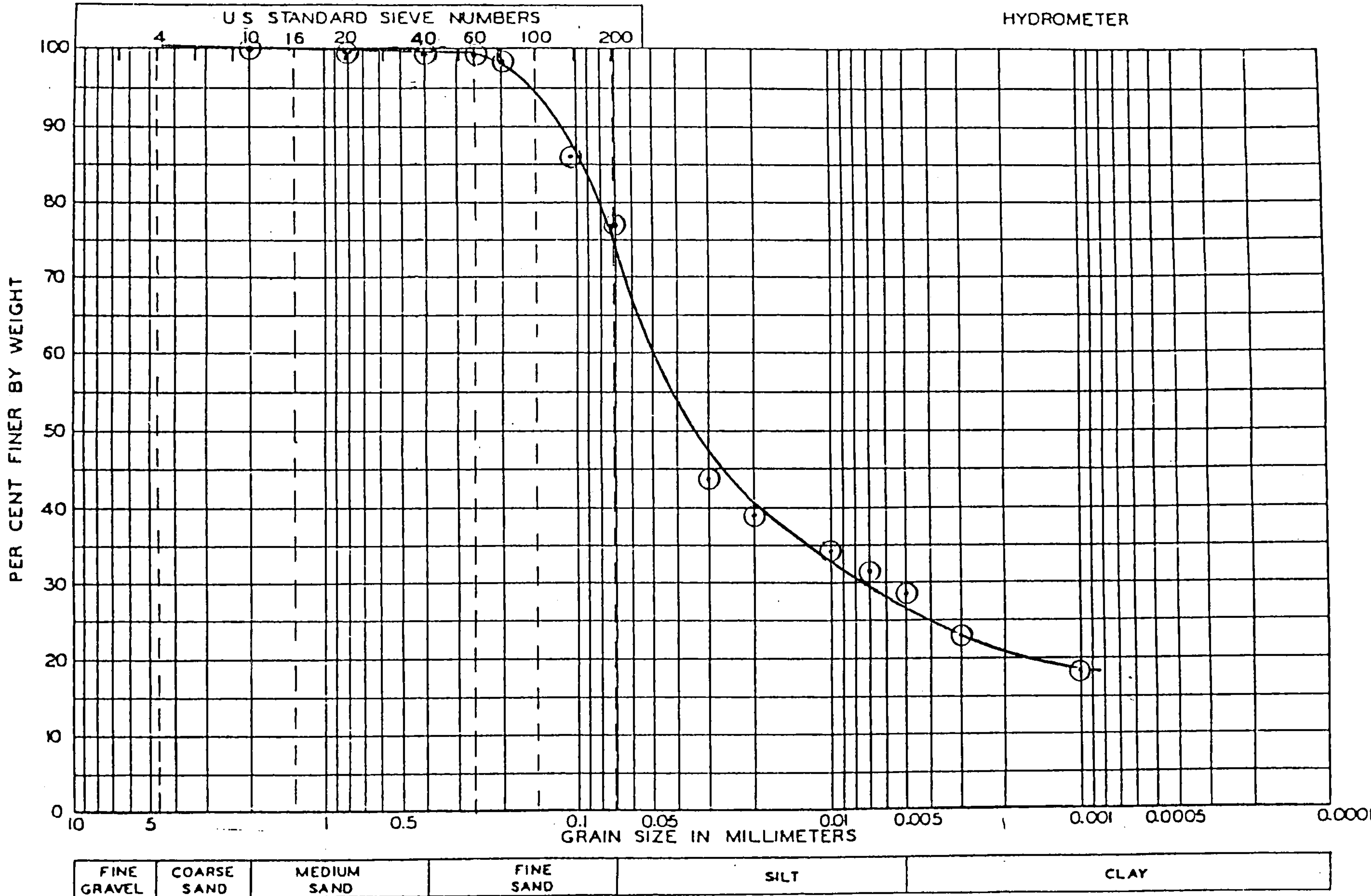
DEPTH 57'-70' ELEVATION ______ REMARKS

BAG SAMPLE

MOISTURE CONTENT: 35.6%

SPECIFIC GRAVITY = 2.66

GRAIN SIZE DISTRIBUTION DIAGRAM



UNIFIED SOIL CLASSIFICATION SYSTEM

PROJECT NAVAL BASE CHARLESTON, S.C., ZONE I RFI INVESTIGATION SOUTHNAVFACENGCOM CONTRACT NO. N62467-89-D-0318-0063

BORING NO ________ SAMPLE NO. NBCC-GRD-02D

DEPTH 70'-85' ELEVATION ______ REMARKS ______

BAG SAMPLE MOISTURE CONTENT: 46.3%

SPECIFIC GRAVITY = 2.65

GRAIN SIZE DISTRIBUTION DIAGRAM

COMPUCHEM
ENVIRONMENTAL
CORPORATION

07/AUG/95

ENSAFE/ALLEN & HOSHALL
ATTN: TINA CANTWELL
5720 SUMMER TREES DR.
CHARLESTON ZONE I CTO 29098440
MEMPHIS, TN 38134

Subject: Report of Data - Account Number 500806

ATTN: TINA CANTWELL

Enclosed are the results of analytical work performed in accordance with the referenced account number.

This report covers 2 sample(s) appearing on the attached listing and their associated Quality Control Data.

Thank you for selecting CompuChem Laboratories for your sample analysis. If you should have questions or require additional analytical services please contact your representative at 1-919-406-1600.

Sincerely,

Report Preparation

Attachment

07/AUG/95

COMPUCHEM
ENVIRONMENTAL
CORPORATION

ENSAFE/ALLEN & HOSHALL
ATTN: TINA CANTWELL
5720 SUMMER TREES DR.
CHARLESTON ZONE I CTO 29098440
MEMPHIS, TN 38134

ACCOUNT #: 500806

CC#	SAMPLE-ID	RECEIPT DATE
731209	688M000101	6/14/95
731225	688M000201	6/14/95

TOTAL NUMBER OF SAMPLES = 2

SAVANNAH LABORATORIES
& ENVIRONMENTAL SERVICES, INC.

900 Lakeside Drive • Mobile, Alabama 36693-5118 • (334) 666-6633 • Fax (334) 666-6696

LOG NO: M5-03445

Received: 15 JUN 95

Ms. Stephanie Winfield
Compuchem Laboratories, Inc./PROJECT-95-14
3306 Chapel Hill/Nelson Hwy
Research Triangle Park, NC 27709

Project: Ensafe/Zone I
Sampled By: Client

REPORT OF RESULTS

Page 1

LOG NO	SAMPLE DESCRIPTION , SOLID OR SEMISOLID SAMPLES		DATE SAMPLED
		Compuchem #'s	
03445-1	688M000101	731209	06-13-95
03445-2	688M000201	731225	06-13-95

PARAMETER	03445-1	03445-2
Grain Size (ASTM D421/422/1140)		
% Passing sieve No.4	80.1 %	97.1 %
% Passing sieve No.10	71.1 %	93.0 %
% Passing sieve No.20	63.3 %	89.2 %
% Passing sieve No.40	56.0 %	83.3 %
% Passing sieve No.60	49.6 %	72.9 %
% Passing sieve No.100	33.4 %	41.9 %
% Passing sieve No.200	20.6 %	23.2 %
% <0.062mm	19 %	22 %
% <0.004mm	10 %	8 %
% <0.001mm	7 %	5 %
Date Analyzed	06.21.95	06.21.95

*Analysis performed by Thompson Engineering; see attached reports.

Michele H. Lersch
Michele H. Lersch

RECEIVED
JUN 30 1995

Final Page Of Report

GRAIN SIZE DISTRIBUTION TEST DATA Test No.: 2

Date: 06/21/95
Project No.: P95053
Project: SAVANNAH #: M5 - 03445-1

Sample Data

Location of Sample: 6BBM000101
Sample Description 1: SILTY MEDIUM TO FINE,
Sample Description 2: WITH LIMESTONE
USCS Class: - - - Liquid limit: - - Plasticity index: - -

Notes

Remarks: CLIENT: SAVANNAH LABORATORIES

Data Sheet No.: 2

Mechanical Analysis Data

	Initial	After wash
Dry sample and tare=	75.46	59.91
Tare =	0.00	0.00
Dry sample weight =	75.46	59.91

Minus #200 from wash= 20.6 %
Tare for cumulative weight retained= 0

Sieve	Cumul. Wt. retained	Percent finer
0.75 inches	0.00	100.0
0.5 inches	4.88	93.5
0.375 inches	8.36	88.9
# 4	15.02	80.1
# 10	21.80	71.1
# 20	27.66	63.3
# 40	33.18	56.0
# 60	38.05	49.6
# 100	50.23	33.4
# 200	59.91	20.6

Hydrometer Analysis Data

Separation sieve is number 10
Percent -# 10 based on complete sample= 71.1
Weight of hydrometer sample: 53.66
Calculated biased weight= 75.46
Table of composite correction values:
Temp, deg C: 20.5 21.7

M5-03445-1

Comp. corr: - 7.0 - 7.0
Meniscus correction only= 0
Specific gravity of solids= 2.65
Specific gravity correction factor= 1.000
Hydrometer type: 152H Effective depth L= 16.294964 - 0.164 x Rm

Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
2.0	21.6	20.0	13.0	0.0134	20.0	13.0	0.0341	17.2
5.0	21.7	19.5	12.5	0.0134	19.5	13.1	0.0216	16.6
15.0	21.7	18.0	11.0	0.0134	18.0	13.3	0.0126	14.6
30.0	21.7	16.5	9.5	0.0134	16.5	13.6	0.0090	12.6
60.0	21.6	16.0	9.0	0.0134	16.0	13.7	0.0064	11.9
250.0	21.7	14.0	7.0	0.0134	14.0	14.0	0.0032	9.3
1440.0	20.5	12.5	5.5	0.0136	12.5	14.2	0.0013	7.3

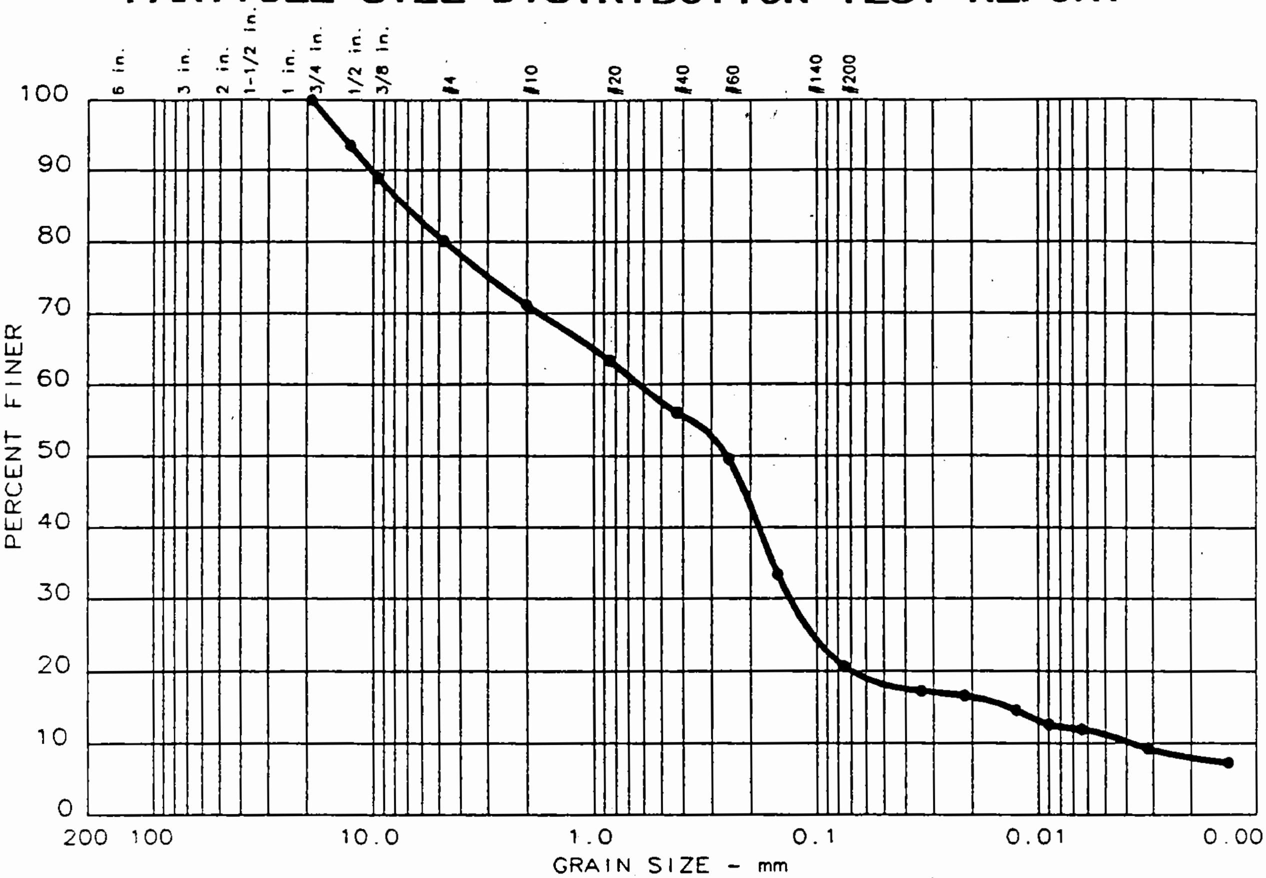
Fractional Components

Gravel/Sand based on #4 sieve
Sand/Fines based on #200 sieve
% + 3 in. = 0.0 % GRAVEL = 19.9 % SAND = 59.5
% SILT = 9.4 % CLAY = 11.2

D85= 7.16 D60= 0.624 D50= 0.254
D30= 0.1318 D15= 0.01349 D10= 0.00376
Cc = 7.4131 Cu = 165.9587

Leroy Bayley
THOMPSON ENGINEERING TESTING, INC.
MATERIALS ENGINEERING LABORATORY

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	0.0	19.9	59.5	9.4	11.2	- - -	- -	- -

SIEVE inches size	PERCENT FINER ●		
0.75	100.0		
0.5	93.5		
0.375	88.9		
	GRAIN SIZE		
D_{60}	0.62		
D_{30}	0.13		
D_{10}	0.00		
	COEFFICIENTS		
C_c	7.41		
C_u	166.0		

SIEVE number size	PERCENT FINER ●		
4	80.1		
10	71.1		
20	63.3		
40	56.0		
60	49.6		
100	33.4		
200	20.6		

Sample information:
● 6BBM000101
SILTY MEDIUM TO FINE,
WITH LIMESTONE

Remarks:
CLIENT: SAVANNAH
LABORATORIES

THOMPSON ENGINEERING

Project No.: P95053
Project: SAVANNAH #: M5 - 03445-1
Date: 06/21/95
Data Sheet No. 2

GRAIN SIZE DISTRIBUTION TEST DATA

Test No.: 1

Date: 06/21/95
Project No.: P95053
Project: SAVANNAH #: M5 - 03445 -2

Sample Data

Location of Sample: 6BBM000201
Sample Description 1: SILTY FINE SAND, TRACE
Sample Description 2: LIMESTONE
USCS Class: - - - Liquid limit: - - Plasticity index: - -

Notes

Remarks: CLIENT: SAVANNAH LABORATORIES

Data Sheet No.: 1

Mechanical Analysis Data

	Initial	After wash
Dry sample and tare=	95.56	73.39
Tare =	0.00	0.00
Dry sample weight =	95.56	73.39

Minus #200 from wash= 23.2 %
Tare for cumulative weight retained= 0

Sieve	Cumul. Wt. retained	Percent finer
0.375 inches	0.00	100.0
# 4	2.81	97.1
# 10	6.65	93.0
# 20	10.29	89.2
# 40	16.00	83.3
# 60	25.85	72.9
# 100	55.53	41.9
# 200	73.39	23.2

Hydrometer Analysis Data

Separation sieve is number 10
Percent -# 10 based on complete sample= 93.0
Weight of hydrometer sample: 88.91
Calculated biased weight= 95.56
Table of composite correction values:

Temp, deg C:	20.5	21.7
Comp. corr:	- 7.0	- 7.0

M5-03445-2

Meniscus correction only= 0
Specific gravity of solids= 2.65
Specific gravity correction factor= 1.000
Hydrometer type: 152H   Effective depth L= 16.294964 - 0.164 x Rm

Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
2.0	21.7	25.0	18.0	0.0134	25.0	12.2	0.0330	18.8
5.0	21.6	23.0	16.0	0.0134	23.0	12.5	0.0212	16.7
15.0	21.7	21.5	14.5	0.0134	21.5	12.8	0.0123	15.2
30.0	21.7	17.0	10.0	0.0134	17.0	13.5	0.0090	10.5
60.0	21.6	17.0	10.0	0.0134	17.0	13.5	0.0063	10.5
250.0	21.7	14.5	7.5	0.0134	14.5	13.9	0.0032	7.8
1440.0	20.5	12.0	5.0	0.0136	12.0	14.3	0.0014	5.2

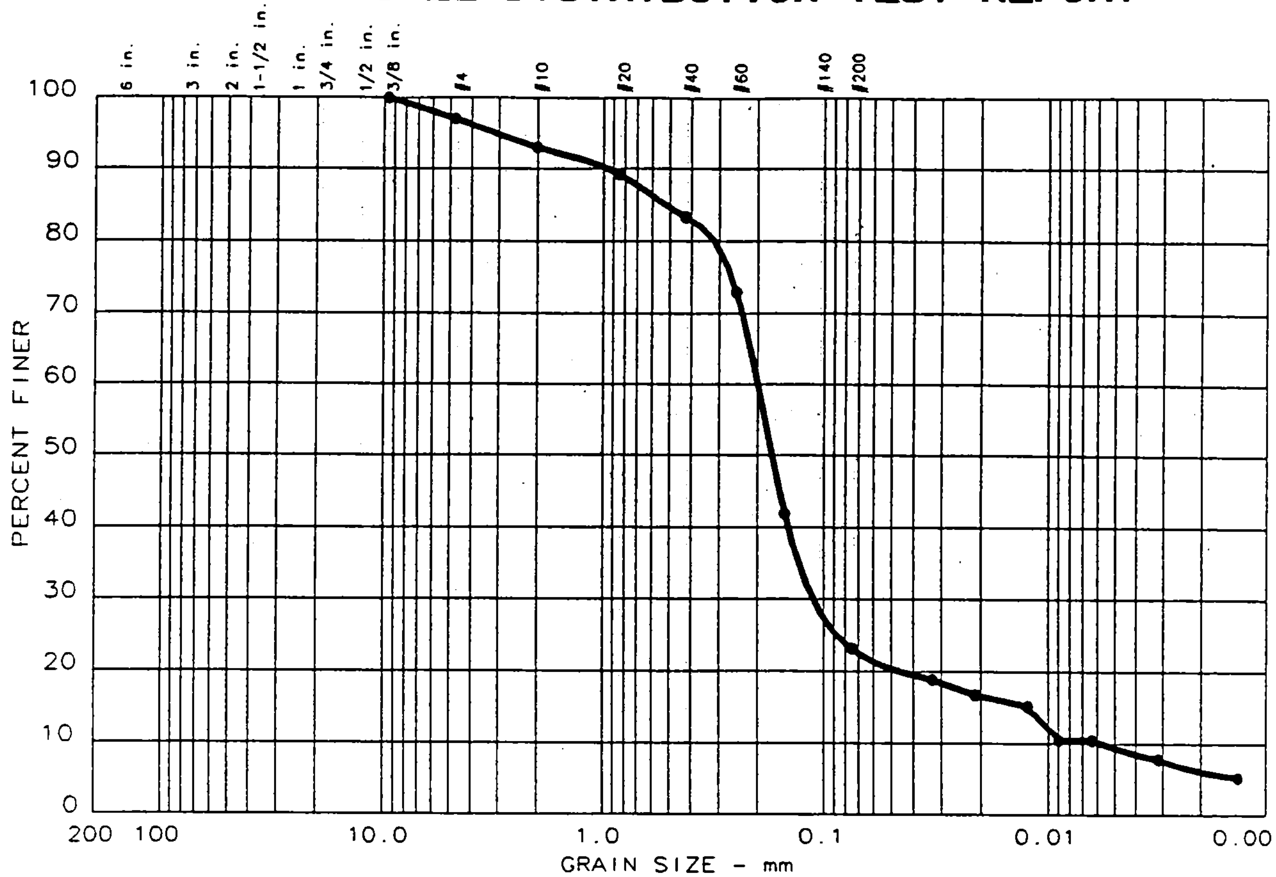
Fractional Components

Gravel/Sand based on #4 sieve
Sand/Fines based on #200 sieve
% + 3 in. = 0.0   % GRAVEL = 2.9   % SAND = 73.9
% SILT = 13.8   % CLAY = 9.4

D85= 0.52 D60= 0.199 D50= 0.171
D30= 0.1117 D15= 0.01211 D10= 0.00560
Cc = 11.1815 Cu = 35.6041

Leroy Bayley
THOMPSON ENGINEERING TESTING, INC.
MATERIALS ENGINEERING LABORATORY

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	0.0	2.9	73.9	13.8	9.4	- - -	- -	- -

SIEVE inches size	PERCENT FINER ●		
0.375	100.0		
	GRAIN SIZE		
D_{60}	0.20		
D_{30}	0.11		
D_{10}	0.00		
	COEFFICIENTS		
C_c	11.18		
C_u	35.6		

SIEVE number size	PERCENT FINER ●		
4	97.1		
10	93.0		
20	89.2		
40	83.3		
60	72.9		
100	41.9		
200	23.2		

Sample information:
● 6BBM000201
SILTY FINE SAND, TRACE LIMESTONE

Remarks:
CLIENT: SAVANNAH LABORATORIES

THOMPSON ENGINEERING

Project No.: P95053
Project: SAVANNAH #: M5 - 03445-2
Date: 06/21/95
Data Sheet No. 1

COMPUCHEM ENVIRONMENTAL CORPORATION
3306 Chapel Hill/Nelson Highway
Research Triangle Park, NC 27709

1-800-833-5097

CHAIN-OF-CUSTODY RECORD

7098

Ship to: SL# 95-14 SAVANNAH LABS	Project Name:	Field Point-of-Contact:
	Sampler Name:	Telephone No.: Sampling for project complete? Y or N (See Note 1)
Carrier: Airbill No.:	Sampler Signature:	Project-specific (PS) or Batch (B) QC:

BOX #1: 1. Surface Water 2. Ground Water 3. Leachate 4. Rinsate 5. Soil / Sediment / Sludge 6. Trip Blank 7. Oil 8. Waste 9. Other

Box #2: A. HCl B. HNO_3 C. $NaHSO_4$ D. $Na_2S_2O_3$ E. Ice Only O. Other N. Not Preserved

Box #3: F. Filtered U. Unfiltered

Box #4: C. CLP 3/90 S. SW-846 W. CWA 600-series L. Low Conc. CLP R. Radiological T. TCLP O. Other

Box #5: H. - High M. - Medium L. - Low

Sample ID (Organics: 9 characters max, Inorganics: 6 characters; See Note 2)	Date: Year: 19__	Time	Box #1 Matrix	Box #2 Preservative	Box #3 Filtered/Unfiltered	Box #4 Method	Box #5 Expect. Conc.	No. of Bottles	Use for Lab QC (MS or DUP)	VOA-GC / MS	SV-GC / MS	Pest / PCB-GC	Herb-GC	VOA-GC			Metals	Mercury	Cyanides		Radiologicals		TOC / TOX	O&G / TPH	Phenols	Other	Remarks / Comments
688M000101	6/13	:	SO																								731209
688M000201	6/13	:	↓																								↓ 225
	/	:																									
	/	:																									
	/	:																									
	/	:																									
	/	:																									
	/	:																									
	/	:																									
	/	:																									

Column groups: Organics Analysis (VOA-GC / MS through VOA-GC); Inorganics (Metals, Mercury, Cyanides); Other (Radiologicals through Other).

Client's Special Instructions:

Lab: Received in Good Condition? Y or N Describe Problems, If Any:

#1 Relinquished By: (Sig.) [signature]	Date: 6/14/95	#2 Relinquished By: (Sig.)	Date:	#3 Relinquished By: (Sig.)	Date:	Sample storage time requested? ____ (In days, see Note 3)
Company Name: CompuChem	Time: 2000	Company Name:	Time:	Company Name:	Time:	
#1 Received By: (Sig.) [signature]	Date: 6/15/95	#2 Received By: (Sig.)	Date:	#3 Received By: (Sig.)	Date:	DESTROY or RETURN data after five years of archival? (Circle choice; see Note 4)
Company Name: Savannah	Time: 1000	Company Name:	Time:	Company Name:	Time:	

Note (1): If "N" lab will hold samples to await remainder of project-maximizing batch size and minimizing QC ratio; if "Y" lab will begin processing batches now. Note (2): If CLP Inorganics diskette required, ID limited to maximum of six characters.
Note (3): ...es stored 60 days after date report mailed at no extra charge. Note (4): All lab copies of data destroyed after five ye... ...less client requests and pays for return of copies; annual storage fee billed in January of year six.

Page 8

03445

ZONE I

CHAIN OF CUSTODY RECORD

EnSafe
5724 SUMMER TREES DR. MEMPHIS, TN 38134 (901)372-7962

PAGE 1 OF 1

CLIENT Naval Base Charleston
ADDRESS Charleston SC
PROJECT NAME/NUMBER 2909.08420
MEDIA STATUS: (A, B, OR C)

PROJECT MANAGER Charlie Vernoy
TELEPHONE NO. 803-884-0029
FAX. NO.
SAMPLERS: (SIGNATURE) [signature]

FIELD SAMPLE NUMBER	DATE	TIME	SAMPLE TYPE	TYPE/SIZE OF CONTAINER	PRESERVATION TEMP.	PRESERVATION CHEMICAL	NO. OF CONTAINERS	VOA	Metals/CN	SVOA, PEST	PCB	TOC	GRAIN Size		REMARKS Temp - 2°
NBCI-688M0001-01	6-13-95	1320	S	2-4oz 2-8oz	4°	NONE	4	X	X	X	X	X	X		
NBCI-688M0002-01 (2 required)	6-13-95	1300	S	2-4oz 2-8oz	4°	NONE	4	X	X	X	X	X	X		ID on Bottles is 688M000201 used Bottle ID on Log sheet 6/14/95
NBCI-688TB001-01	6-13-95	1420	W	3-40ml	4°	HCL	3	X							

RELINQUISHED BY:	DATE	~~RELINQUISHED~~ RECD BY:	DATE	~~RELINQUISHED~~ RECD BY:	DATE	RELINQUISHED BY:	DATE
SIGNATURE [signature]	6-13-95	SIGNATURE [signature]	6/14/95	SIGNATURE [signature]	6/15/95	SIGNATURE	
PRINTED J. Watson, Sr	TIME	PRINTED C. Phelps	TIME	PRINTED Bryan McGeoghan	TIME	PRINTED	TIME
COMPANY EnSafe	1420	COMPANY CompuChem	8:30	COMPANY Savannah	1010	COMPANY	
REASON Ship to Lab		REASON		REASON Analysis		REASON	

METHOD OF SHIPMENT: Federal Express
SHIPMENT NO. 4539290114
SPECIAL INSTRUCTION:

COMMENTS:

AFTER ANALYSIS, SAMPLES ARE TO BE:
- ☐ DISPOSED OF (ADDITIONAL FEE)
- ☐ STORED (90 DAYS MAX)
- ☐ STORED OVER 90 DAYS (ADDITIONAL FEE)
- ☐ RETURNED TO CUSTOMER

CHANCUST

CompuChem Environmental Corporation
SUBCONTRACT / GHOST SAMPLE
ANALYSIS REQUEST FORM

Page 1 of 1

ZONE I

P.O. BOX 14998, 3306 Chapel Hill/Nelson Highway, Research Triangle Park, NC 27709 (919) 406-1600

RECEIPT DATE : 6-14-95	CompuChem PROJECT TEAM
TURNAROUND REQ'D:	PROJ. MGR. : STEPHANIE WINFREE ext. 2456
REPORT DUE DATE :	SALES REP. : ext.
SL#95-14	CUST. SRV. REP. : CATHY DOVER ext. 1627

#	L/I*	SAMPLE ID	CCN	ANALYSIS	METHOD	QA/QC	DET. LIMIT	HOLDING TIME
1		688m000101	731~~209~~	GRAINSIZE		Std	Std	Std
2		688m000201	731225	↓		✓	✓	✓
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								

M.S. 6/14/95

*LAB INSTRUCTIONS (L/I):

SAMPLES INVOLVED IN LITIGATION ? Y or N

LATE DATA IS SUBJECT TO PENALTY ? Y or N — If YES, penalty = _______% per day!!

REPORTING REQUIREMENTS :

DISKETTE REQUIRED ? Y or N

DISKETTE FORMAT : FLAT ASCII FILE

SUBCONTRACT LAB INFORMATION:

LAB NAME : SAVANNAH LABS

ADDRESS : 900 LAKESIDE DR.

MOBILE, AL

PHONE # :

FAX # :

CONTACT PERSON : M. LERSCH

FAX & MAIL TO SUBCONTRACTOR

END

OF

REPORT

Aerostar
Environmental Services, Inc.

August 28, 1997

Mr. Levin Ham
ENSAFE/ALLEN & HOSHALL
935 Houston Northcutt Boulevard
Mt. Pleasant, South Carolina 29464

RE: Geotechnical Laboratory Analyses
Navbase Charleston
Charleston, South Carolina

Dear Mr. Ham:

Aerostar Environmental Services, Inc. **(AEROSTAR)** has completed laboratory permeability (ASTM D5084 or USACOE EM1110), grain size (ASTM D422), percent moisture, and specific gravity (ASTM D854) tests for soil samples submitted to us on August 8, 1997. Bulk density and porosity were calculated from the data obtained from these tests. The results of the testing are presented in the following table and on the attached Grain Size Distribution Test Reports.

Sample ID	**Specific Gravity**	**Porosity (%)**	**Moisture Content (%)**	**Dry Density (PCF)**	**Coefficient of Permeability (cm/sec)**
508-2	2.658	49.9	7.9	91.0	4.7×10^{-3}
511-2	2.664	49.9	9.6	92.4	3.0×10^{-3}
512-2	2.630	49.8	92.2	46.1	1.5×10^{-6}
512-3	2.629	49.9	37.1	80.0	8.0×10^{-8}

AEROSTAR appreciates the opportunity to provide you with our services. Please feel free to contact us with questions you may have.

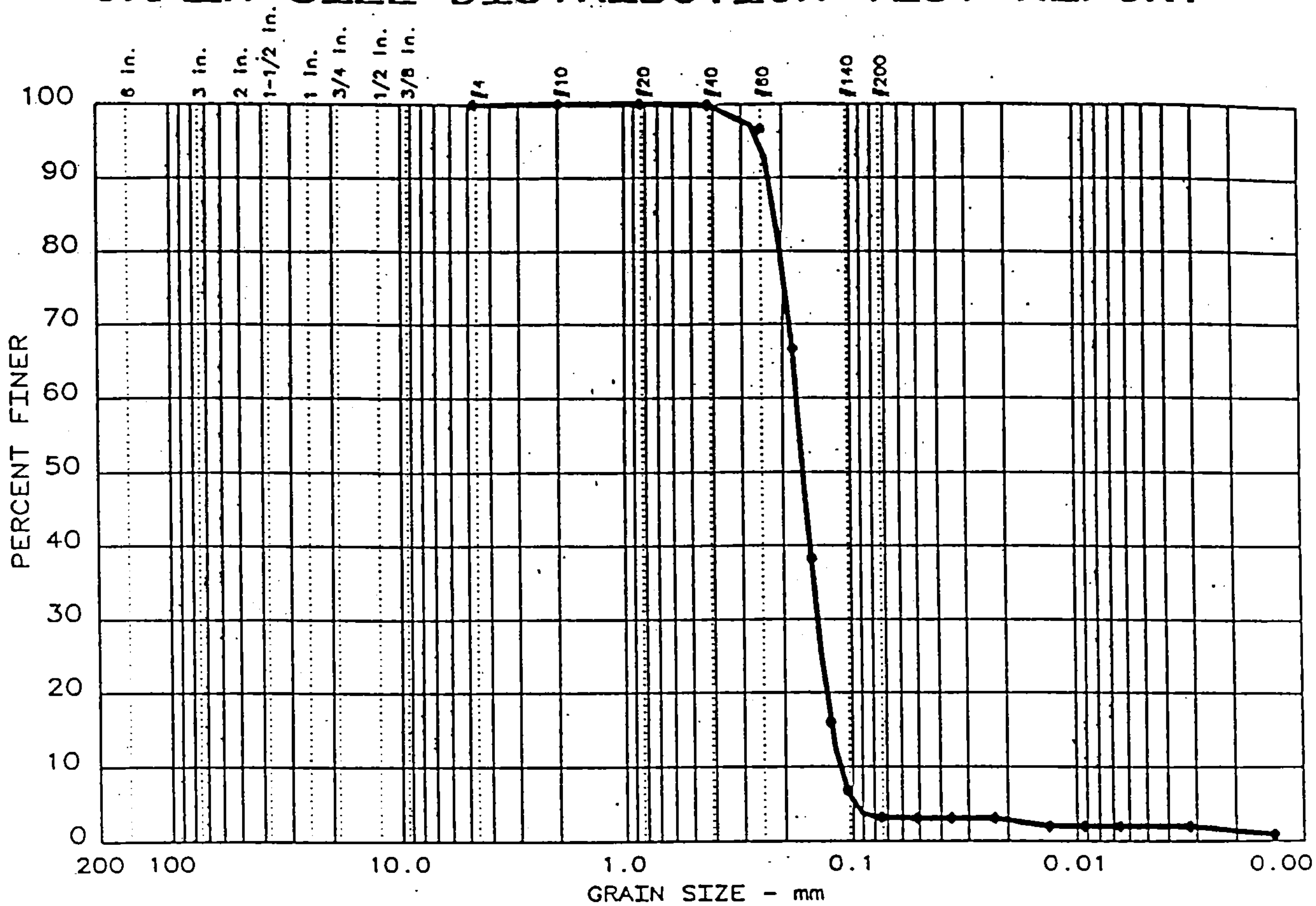
Sincerely,

AEROSTAR ENVIRONMENTAL SERVICES, INC.

Richard M. Dasher

Richard M. Dasher, PE, PG

GRAIN SIZE DISTRIBUTION TEST REPORT



	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	0.0	96.8	1.2	2.0

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.216	0.172	0.162	0.142	0.123	0.114	1.02	1.5

MATERIAL DESCRIPTION	USCS	AASHTO
● Brown Fine SAND w/ a trace of silt and clay	SP	A-3

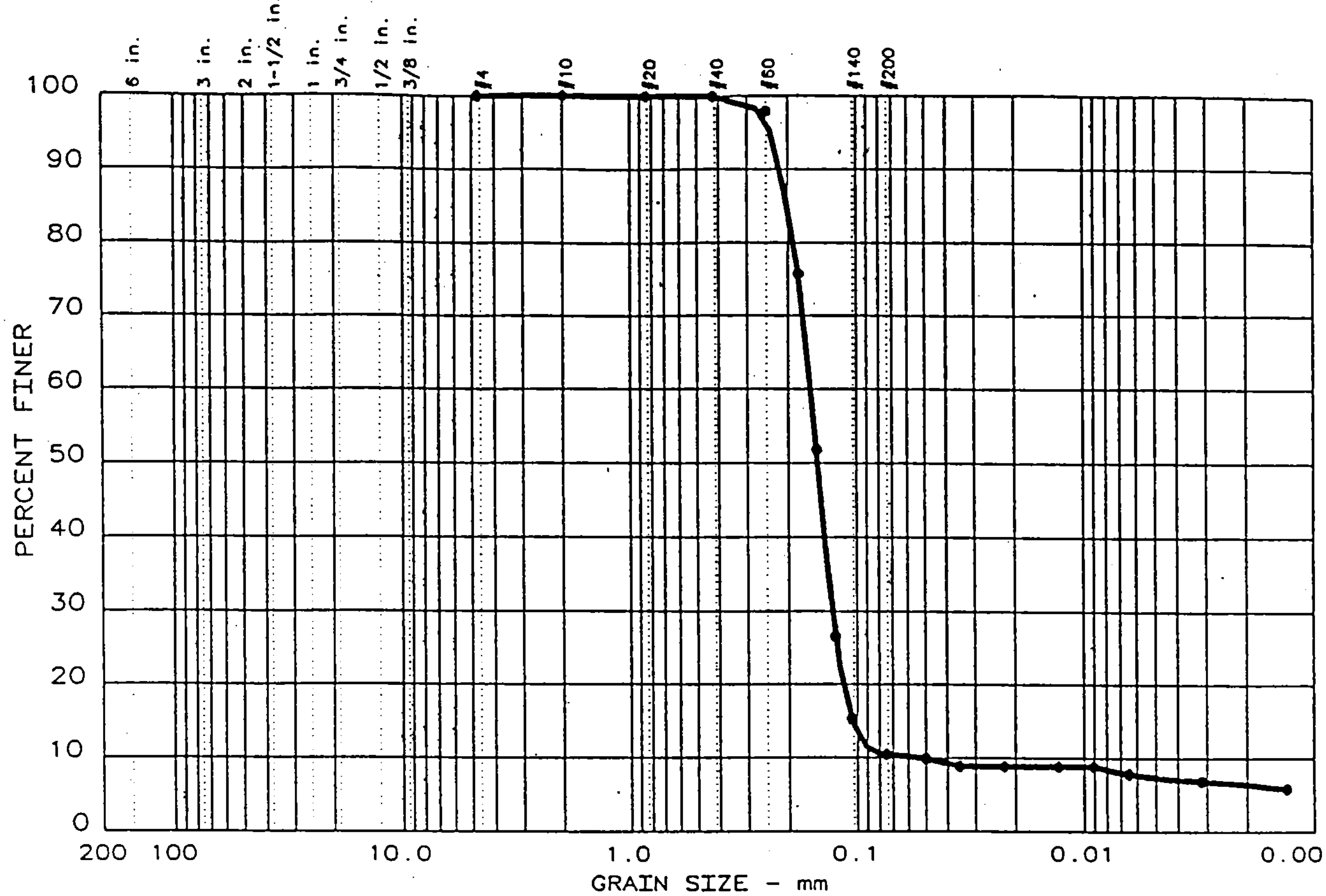
Aerostar Environmental Services, Inc.

NAVBASE CHARLESTON
CHARLESTON, SOUTH CAROLINA

GRAIN SIZE DISTRIBUTION TEST REPORT

SAMPLE NO. 508-2

GRAIN SIZE DISTRIBUTION TEST REPORT



	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	0.0	89.5	3.2	7.3

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.203	0.159	0.148	0.129	0.105	0.0530	1.97	3.0

MATERIAL DESCRIPTION	USCS	AASHTO
● Brown Slightly Silty Slightly Clayey Fine SAND	SP-SM	A-2-4

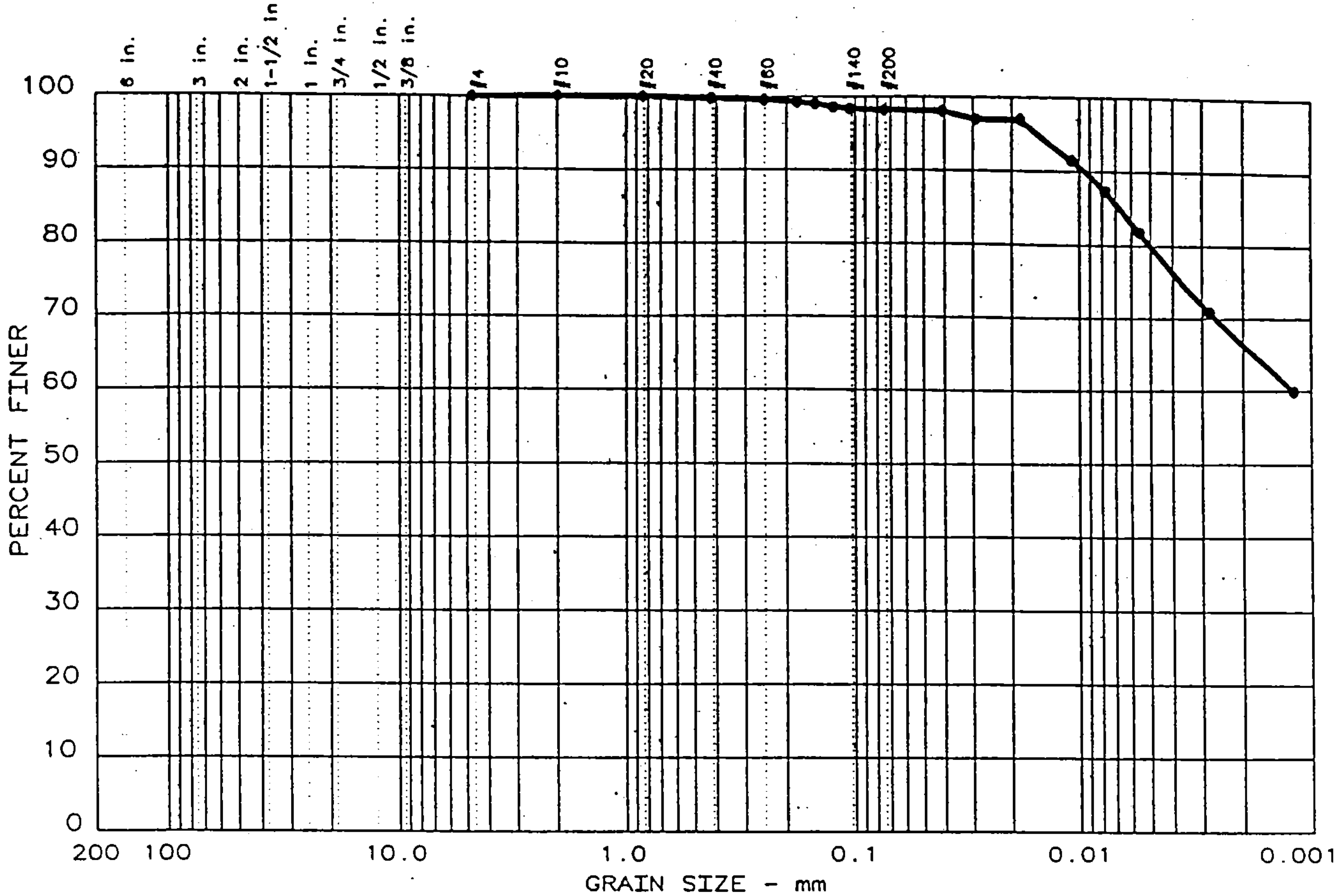
Aerostar Environmental Services, Inc.

NAVBASE CHARLESTON
CHARLESTON, SOUTH CAROLINA

GRAIN SIZE DISTRIBUTION TEST REPORT

SAMPLE NO. 511-2

GRAIN SIZE DISTRIBUTION TEST REPORT



	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	0.0	1.8	18.1	80.1

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●										

MATERIAL DESCRIPTION	USCS	AASHTO
● Dark Grey Silty CLAY w/ a trace of fine sand	ML	A-4

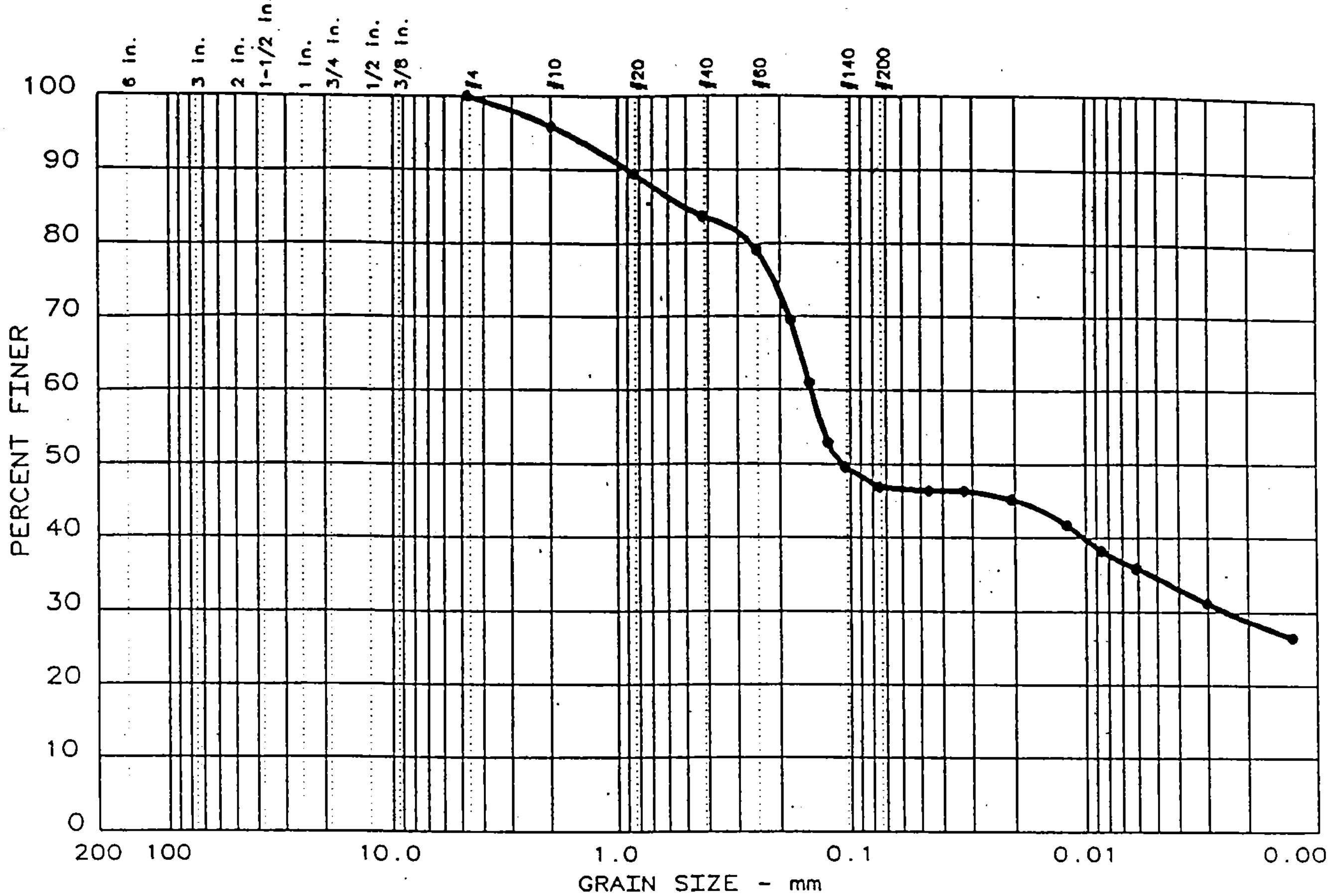
Aerostar Environmental Services, Inc.

NAVBASE CHARLESTON
CHARLESTON, SOUTH CAROLINA

GRAIN SIZE DISTRIBUTION TEST REPORT

SAMPLE NO. 512-2

GRAIN SIZE DISTRIBUTION TEST REPORT



	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	0.0	53.1	12.4	34.5

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.513	0.147	0.109	0.0024				

MATERIAL DESCRIPTION	USCS	AASHTO
● Grey Silty Clayey Fine SAND w/ rock fragments	SM	A-4

Aerostar Environmental Services, Inc.

NAVBASE CHARLESTON
CHARLESTON, SOUTH CAROLINA

GRAIN SIZE DISTRIBUTION TEST REPORT

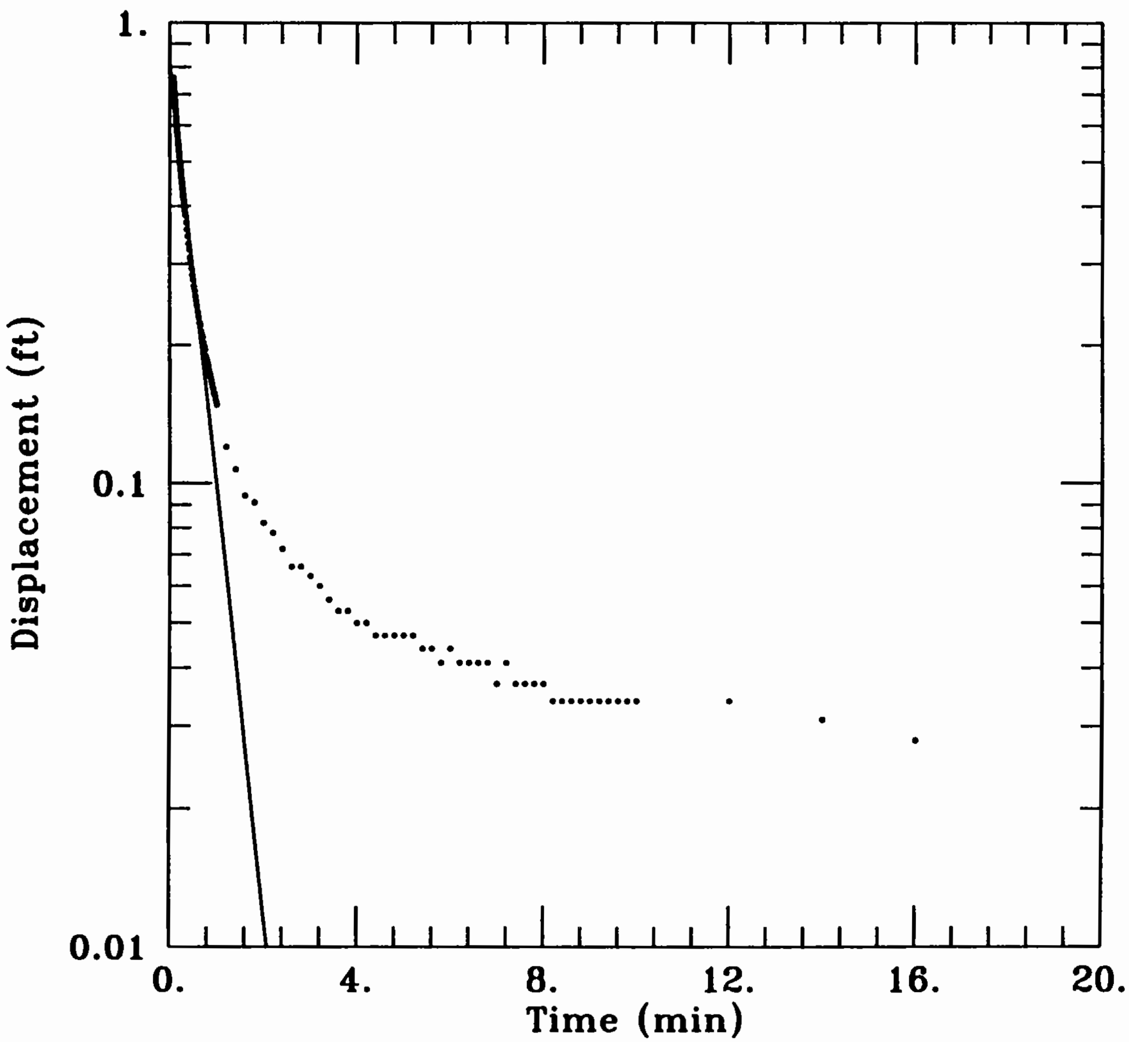
SAMPLE NO. 512-3

Appendix C

Zone C
Aquifer Characterization Data

Client: **NAVBASE Charleston**	Company: **EnSafe/Allen & Hoshall**
Location: **Zone C**	Project: **2903-12210**

044001



DATA SET:
0441RIS.AQT
08/31/95

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

PROJECT DATA:
test date: June 16, 1995
test well: Rising Head

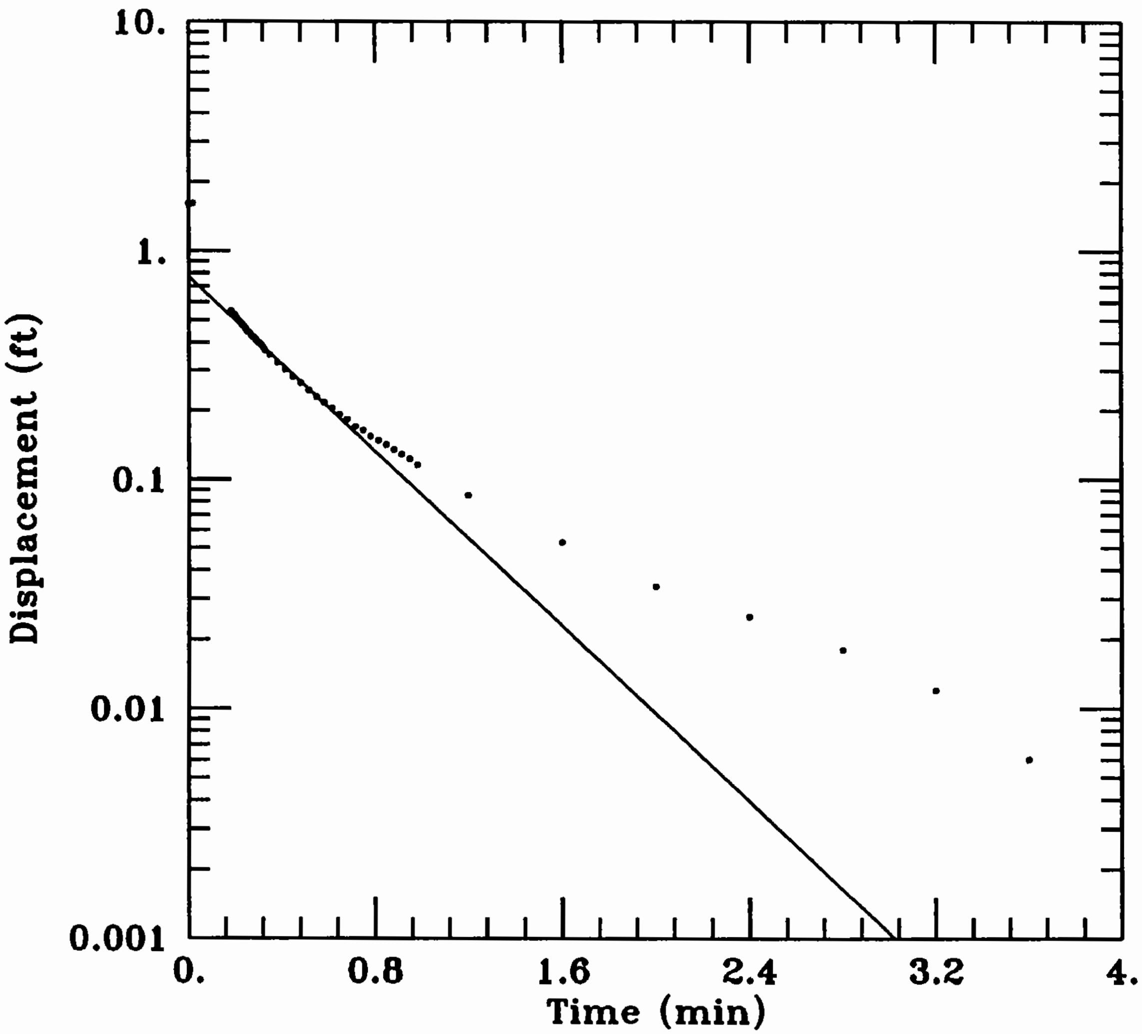
TEST DATA:
H0 = 1.414 ft
rc = 0.0833 ft
rw = 0.333 ft
L = 10. ft
b = 10.5 ft
H = 10.5 ft

PARAMETER ESTIMATES:
K = 0.001908 ft/min
y0 = 0.8155 ft

AQTESOLV

Client: **NAVBASE Charleston**	Company: **EnSafe/Allen & Hoshall**
Location: **Zone C**	Project: **2903-12210**

044001



DATA SET:
0441FAL.AQT
01/16/96

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

PROJECT DATA:
test date: June 16, 1995
test well: Falling Head

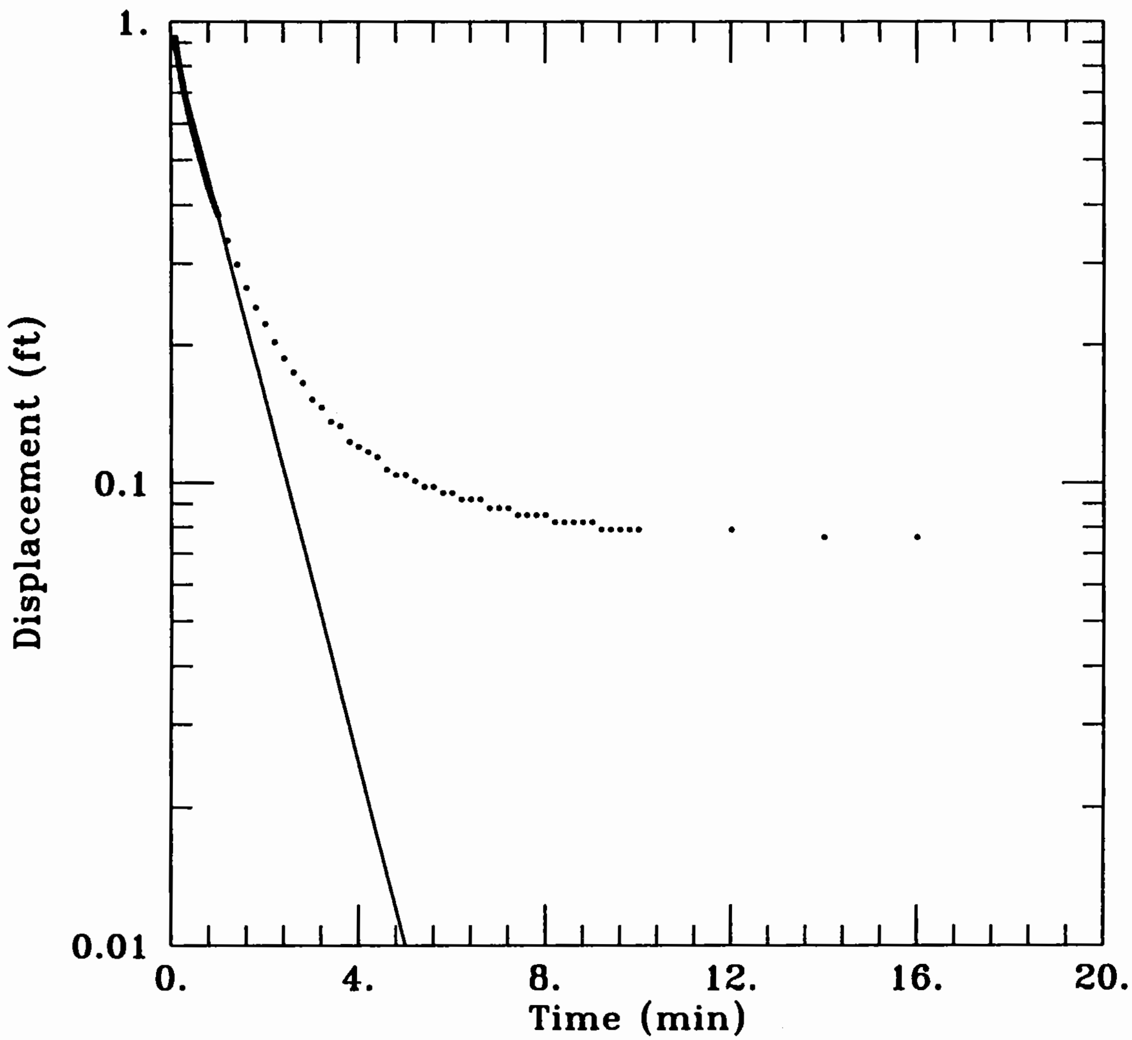
TEST DATA:
H0 = 1.607 ft
rc = 0.0833 ft
rw = 0.333 ft
L = 10. ft
b = 10.5 ft
H = 10.5 ft

PARAMETER ESTIMATES:
K = 0.001986 ft/min
y0 = 0.7738 ft

AQTESOLV

Client: **NAVBASE Charleston**	Company: **EnSafe/Allen & Hoshall**
Location: **Zone C**	Project: **2903-12210**

044006



DATA SET:
0446RIS.AQT
08/31/95

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

PROJECT DATA:
test date: June 16, 1995
test well: Rising Head

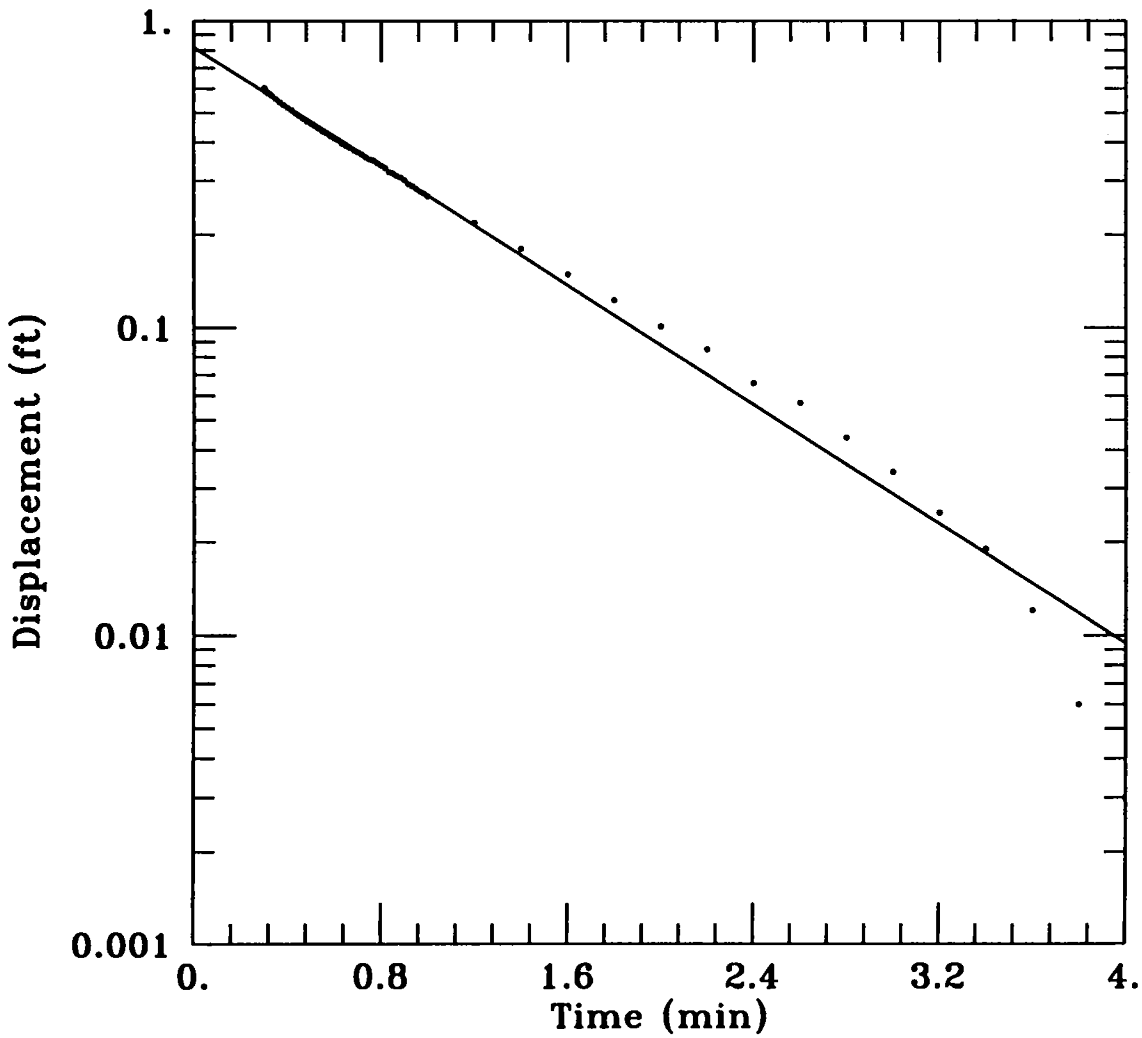
TEST DATA:
H0 = 1.684 ft
rc = 0.0833 ft
rw = 0.333 ft
L = 10. ft
b = 12.07 ft
H = 12.07 ft

PARAMETER ESTIMATES:
K = 0.0008453 ft/min
y0 = 0.934 ft

AQTESOLV

Client: **NAVBASE Charleston**	Company: **EnSafe/Allen & Hoshall**
Location: **Zone C**	Project: **2903-12210**

044006



DATA SET:
0446FAL.AQT
08/31/95

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

PROJECT DATA:
test date: June 16, 1995
test well: Falling Head

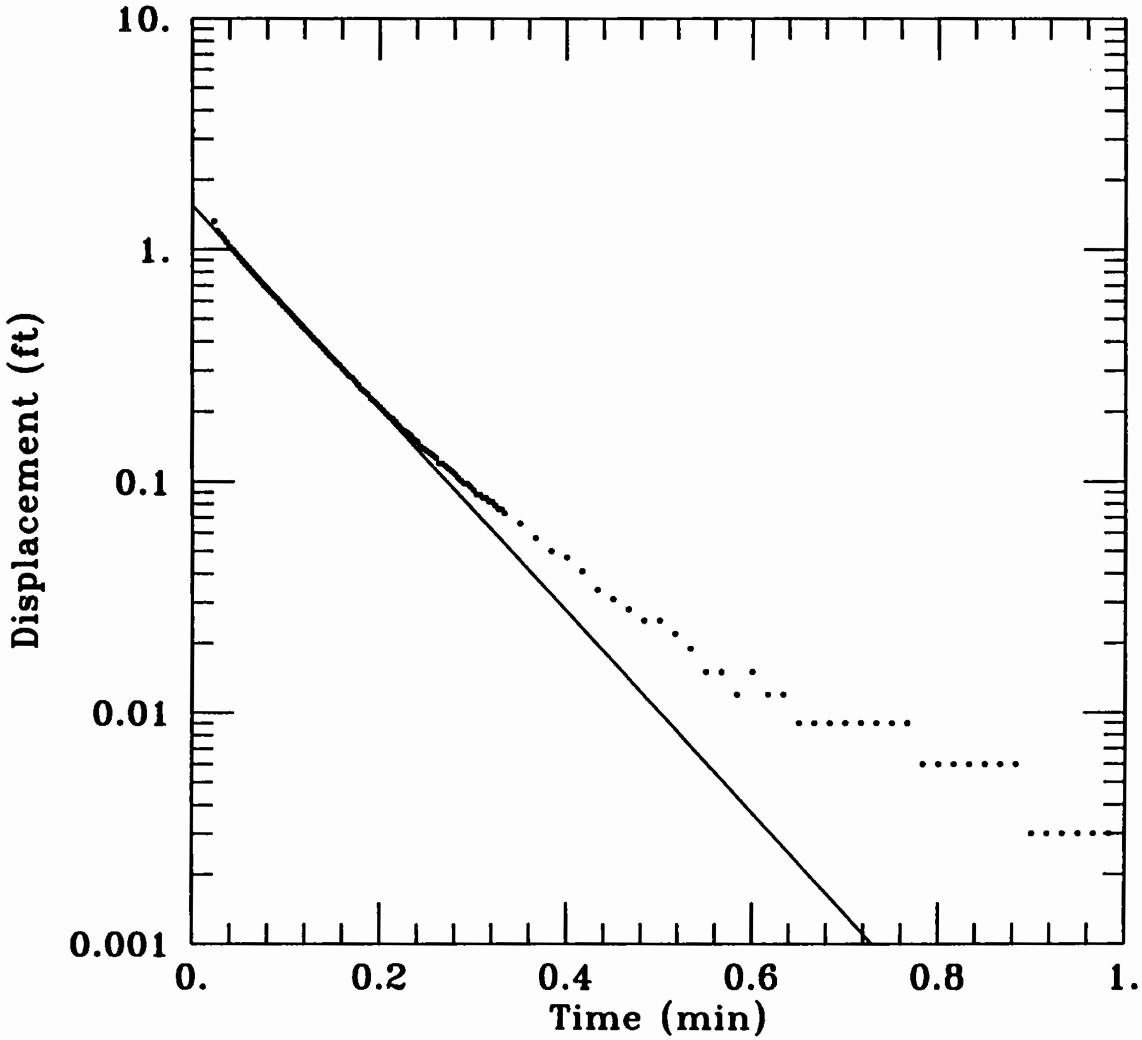
TEST DATA:
H0 = 1.086 ft
rc = 0.0833 ft
rw = 0.333 ft
L = 10. ft
b = 12.07 ft
H = 12.07 ft

PARAMETER ESTIMATES:
K = 0.001041 ft/min
y0 = 0.8179 ft

AQTESOLV

Client: **NAVBASE Charleston**	Company: **EnSafe/Allen & Hoshall**
Location: **Zone C**	Project: **2903-12210**

047001



DATA SET:
0471RIS.AQT
08/31/95

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

PROJECT DATA:
test date: June 16, 1995
test well: Rising Head

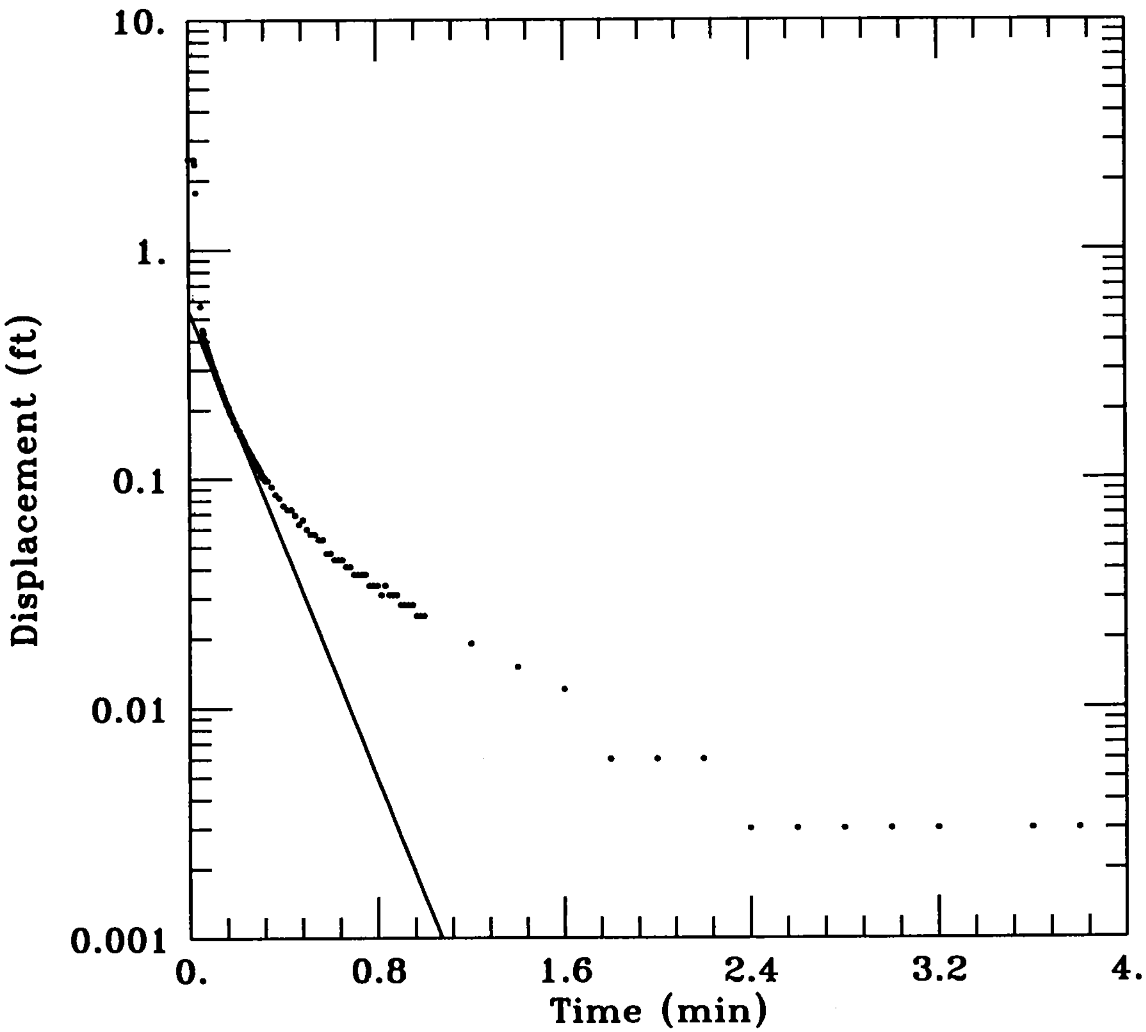
TEST DATA:
H0 = 3.263 ft
rc = 0.0833 ft
rw = 0.333 ft
L = 8.7 ft
b = 8.7 ft
H = 8.7 ft

PARAMETER ESTIMATES:
K = 0.009843 ft/min
y0 = 1.544 ft

AQTESOLV

Client: **NAVBASE Charleston**	Company: **EnSafe/Allen & Hoshall**
Location: **Zone C**	Project: **2903-12210**

047001



DATA SET:
0471FAL.AQT
01/16/96

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

PROJECT DATA:
test date: June 16, 1995
test well: Falling Head

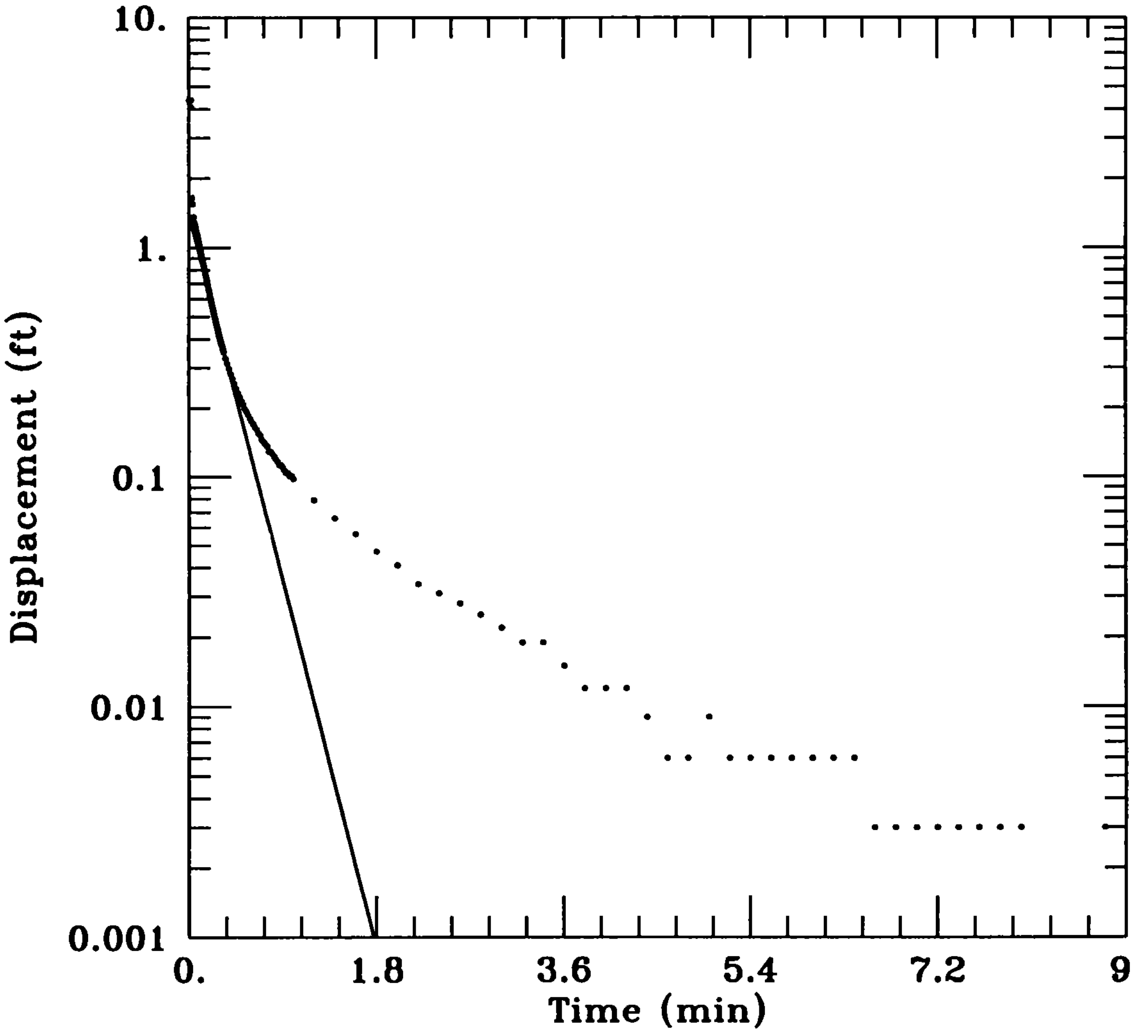
TEST DATA:
$H0 = 2.47$ ft
$rc = 0.083$ ft
$rw = 0.35$ ft
$L = 8.7$ ft
$b = 8.7$ ft
$H = 8.7$ ft

PARAMETER ESTIMATES:
$K = 0.005593$ ft/min
$y0 = 0.5388$ ft

AQTESOLV

Client: **NAVBASE Charleston**	Company: **EnSafe/Allen & Hoshall**
Location: **Zone C**	Project: **2903-12210**

047003



DATA SET:
0473RIS.AQT
01/16/96

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

PROJECT DATA:
test date: June 16, 1995
test well: Rising Head

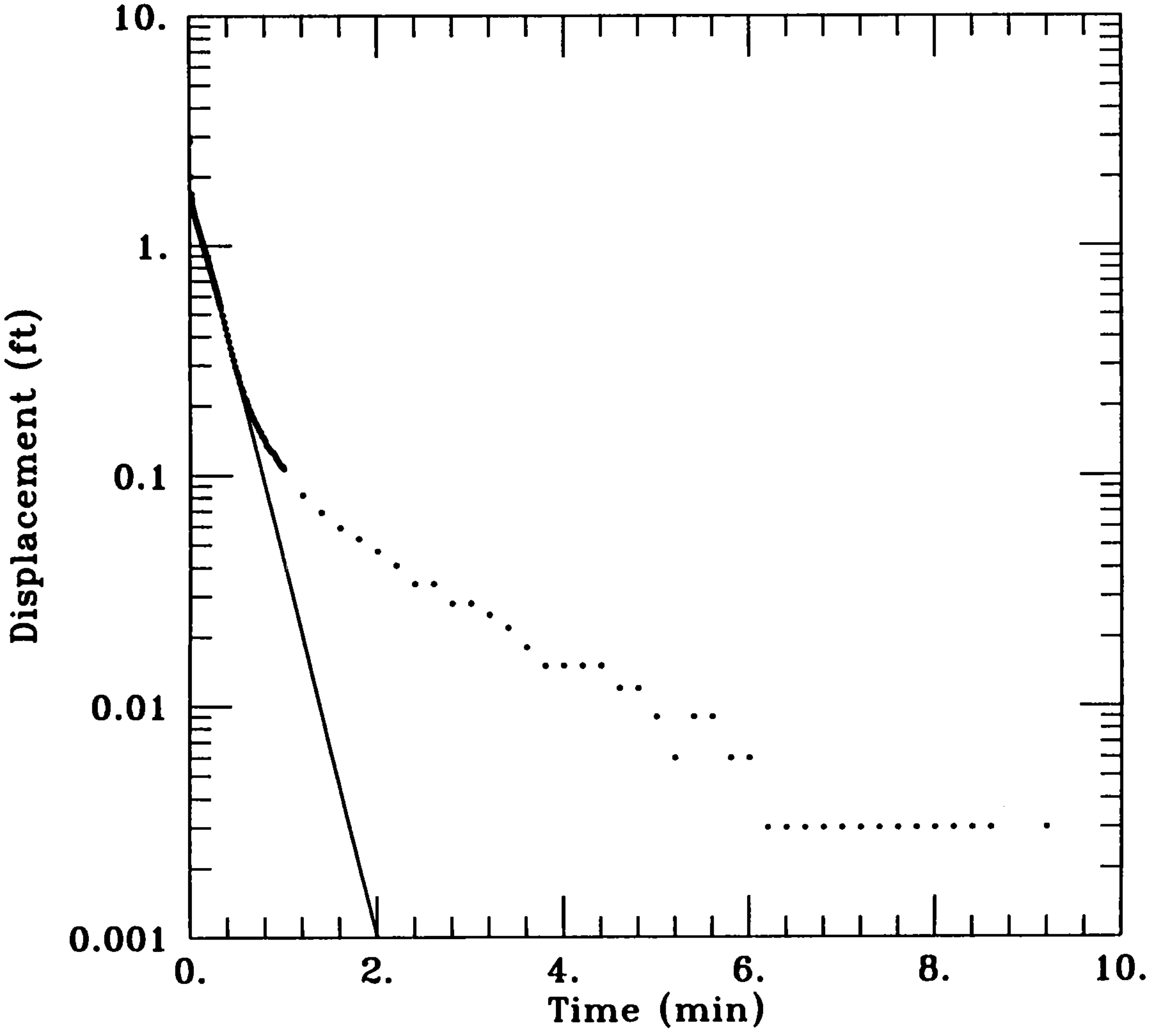
TEST DATA:
H0 = 4.369 ft
rc = 0.0833 ft
rw = 0.35 ft
L = 10. ft
b = 10.3 ft
H = 10.3 ft

PARAMETER ESTIMATES:
K = 0.003599 ft/min
y0 = 1.381 ft

AQTESOLV

Client: NAVBASE Charleston	Company: EnSafe/Allen & Hoshall
Location: Zone C	Project: 2903-12210

047006



DATA SET:
0476RIS.AQT
08/31/95

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

PROJECT DATA:
test date: June 16, 1995
test well: Rising Head

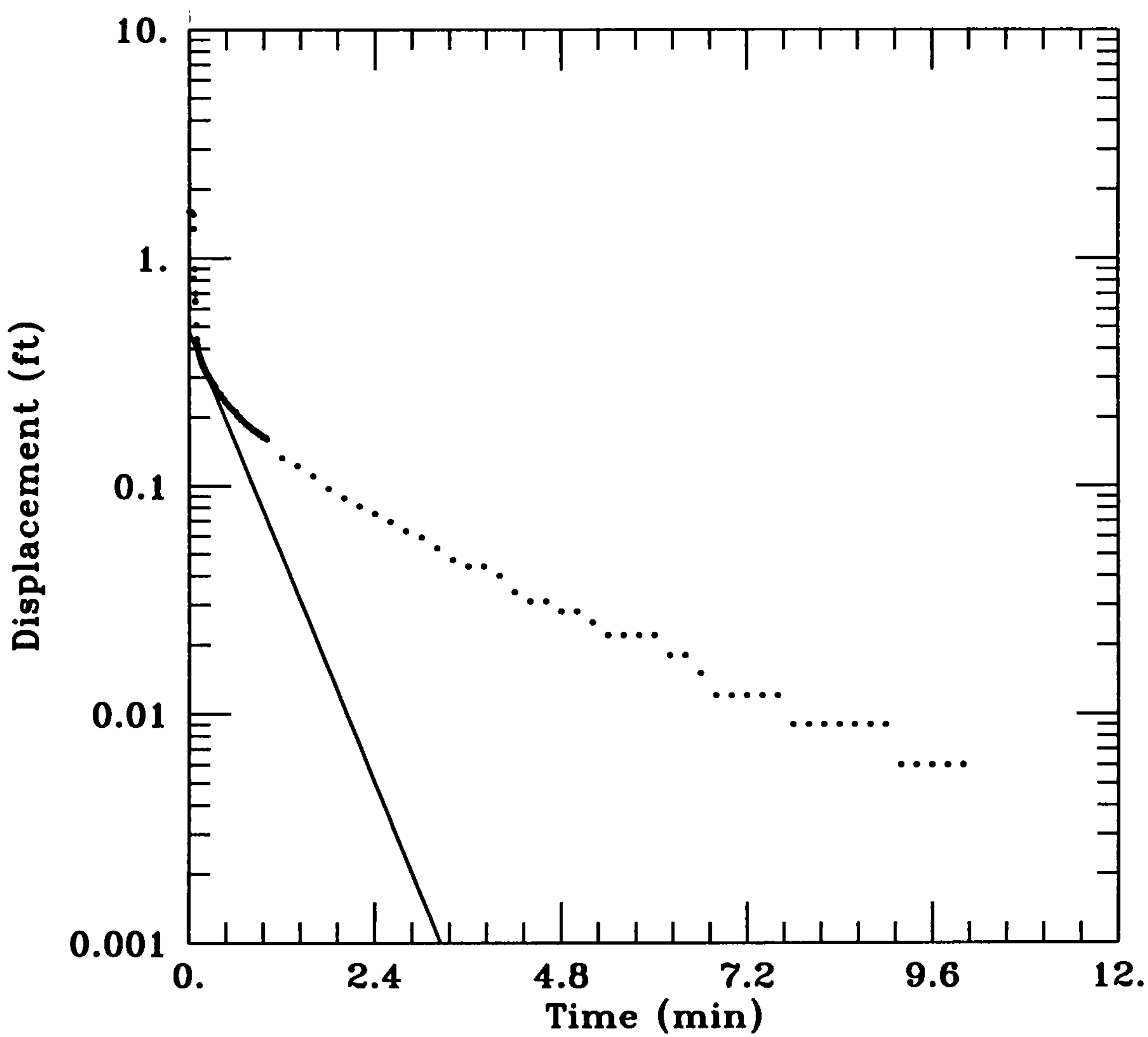
TEST DATA:
H0 = 2.85 ft
rc = 0.083 ft
rw = 0.35 ft
L = 7.4 ft
b = 7.4 ft
H = 7.4 ft

PARAMETER ESTIMATES:
K = 0.003937 ft/min
y0 = 1.766 ft

AQTESOLV

Client: **NAVBASE Charleston**	Company: **EnSafe/Allen & Hoshall**
Location: **Zone C**	Project: **2903-12210**

047006



DATA SET:
0476FAL.AQT
01/16/96

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

PROJECT DATA:
test date: June 16, 1995
test well: Falling Head

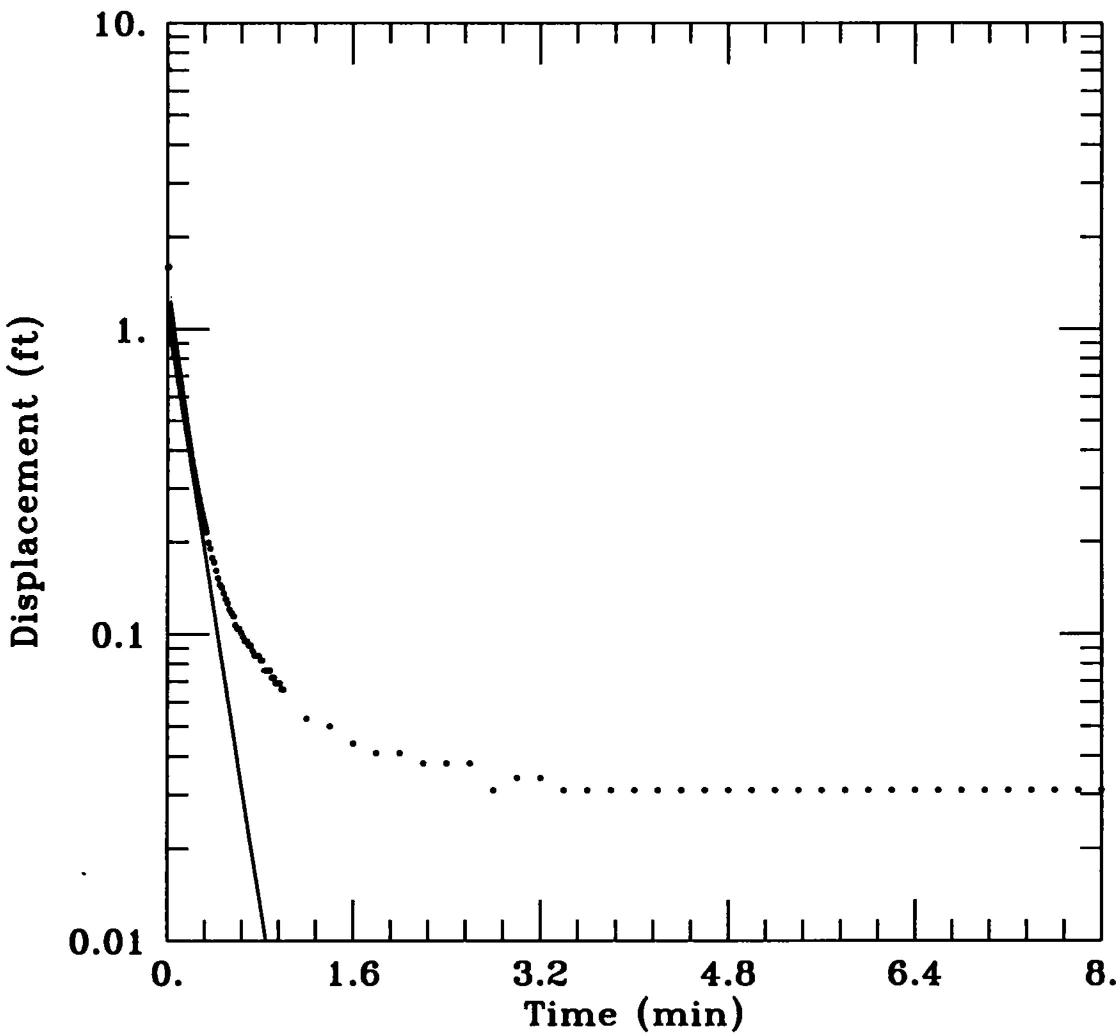
TEST DATA:
H0 = 1.6 ft
rc = 0.0833 ft
rw = 0.35 ft
L = 7.4 ft
b = 7.4 ft
H = 7.4 ft

PARAMETER ESTIMATES:
K = 0.002016 ft/min
y0 = 0.474 ft

AQTESOLV

Client: **NAVBASE Charleston**	Company: **EnSafe/Allen & Hoshall**
Location: **Zone C**	Project: **2903-12210**

510-01



DATA SET:
51001RIS.AQT
01/16/96

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

PROJECT DATA:
test date: June 16, 1995
test well: Rising Head

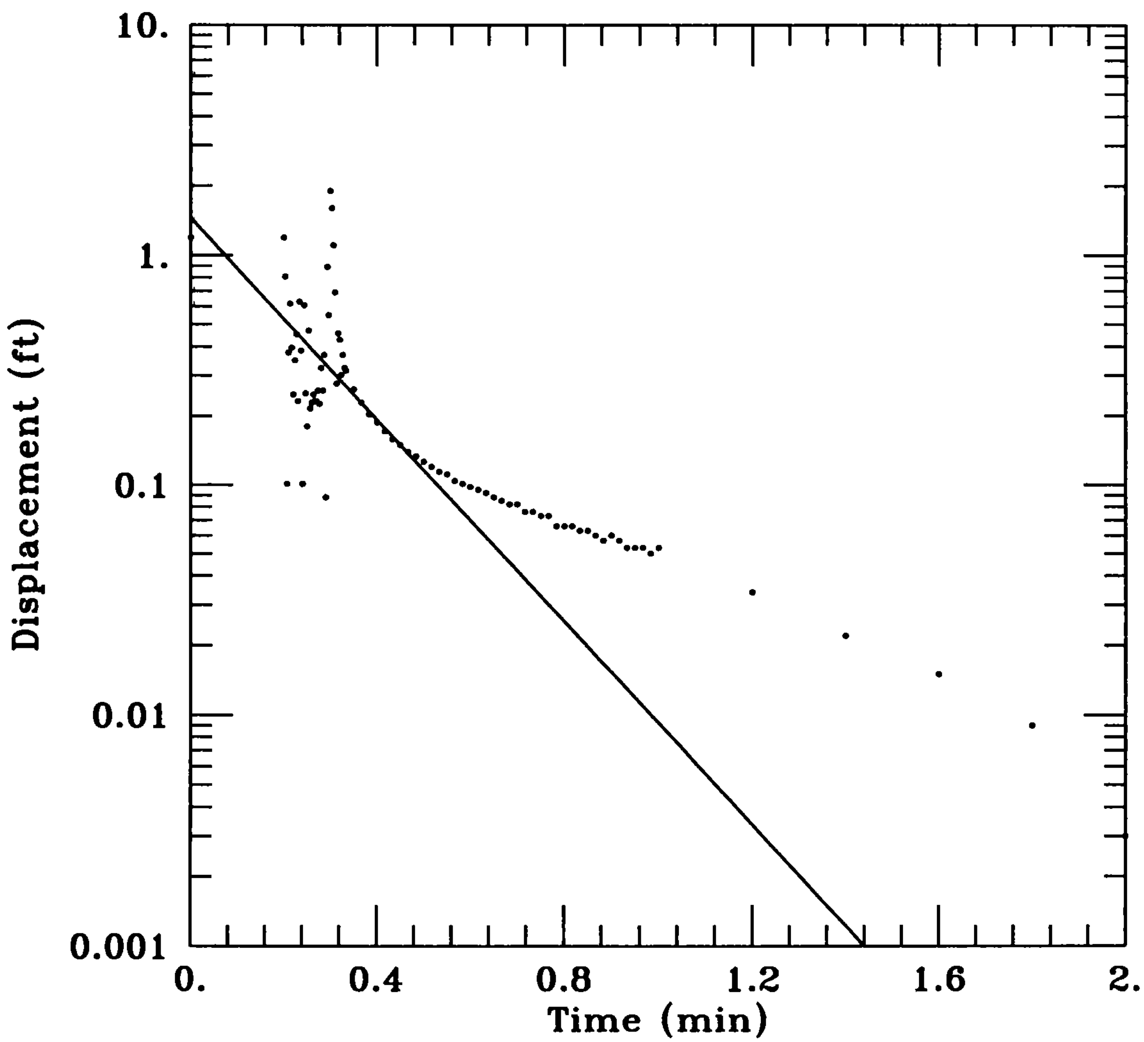
TEST DATA:
H0 = 1.59 ft
rc = 0.083 ft
rw = 0.35 ft
L = 5.9 ft
b = 5.9 ft
H = 5.9 ft

PARAMETER ESTIMATES:
K = 0.006649 ft/min
y0 = 1.062 ft

AQTESOLV

Client: **NAVBASE Charleston**	Company: **EnSafe/Allen & Hoshall**
Location: **Zone C**	Project: **2903-12210**

510-01



DATA SET:
51001FAL.AQT
01/16/96

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

PROJECT DATA:
test date: June 16, 1995
test well: Falling Head

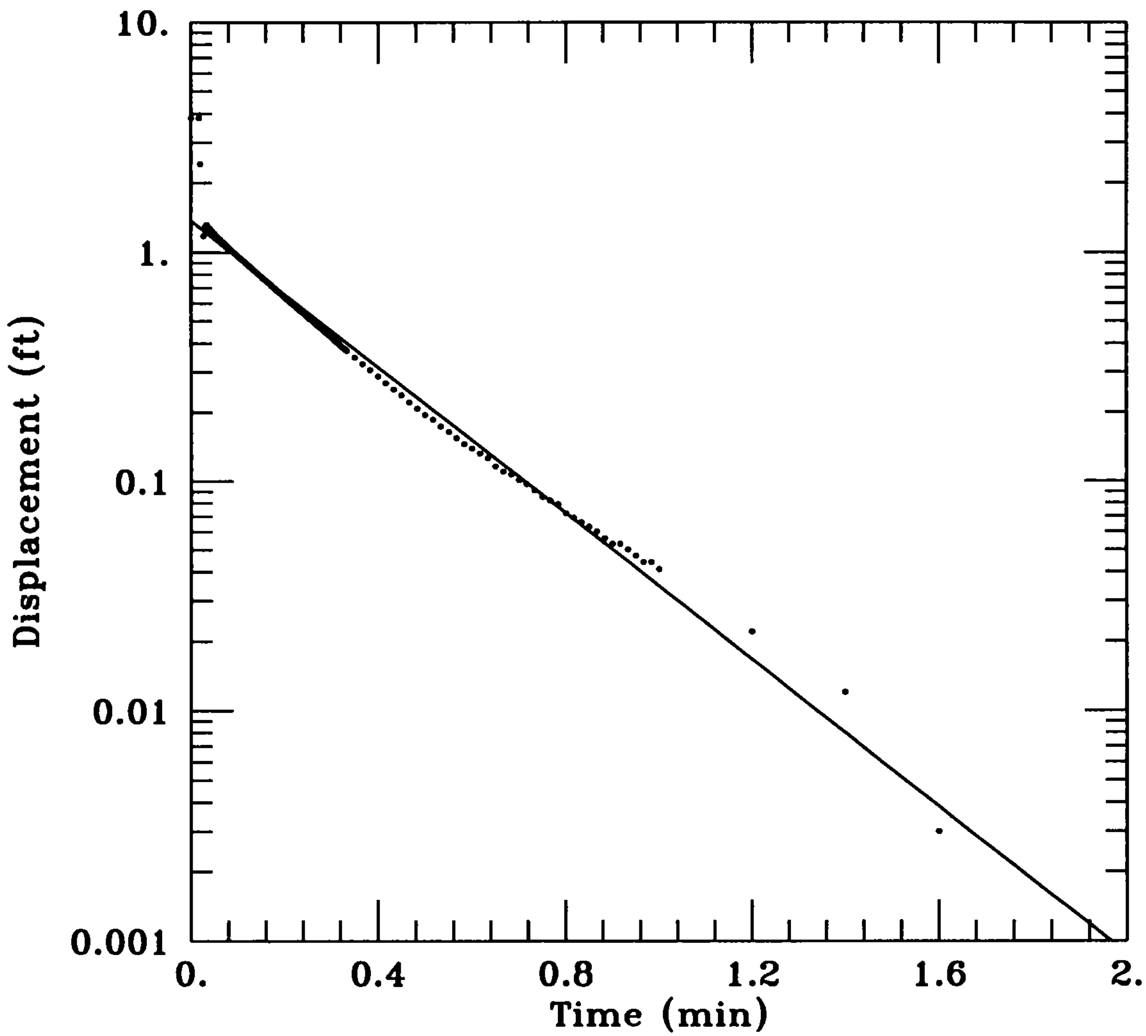
TEST DATA:
H0 = 1.19 ft
rc = 0.083 ft
rw = 0.35 ft
L = 5.9 ft
b = 5.9 ft
H = 5.9 ft

PARAMETER ESTIMATES:
K = 0.00612 ft/min
y0 = 1.446 ft

AQTESOLV

Client: **NAVBASE Charleston**	Company: **EnSafe/Allen & Hoshall**
Location: **Zone C**	Project: **2903-12210**

523-01



DATA SET:
52301RIS.AQT
01/16/96

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

PROJECT DATA:
test date: June 16, 1995
test well: Rising Head

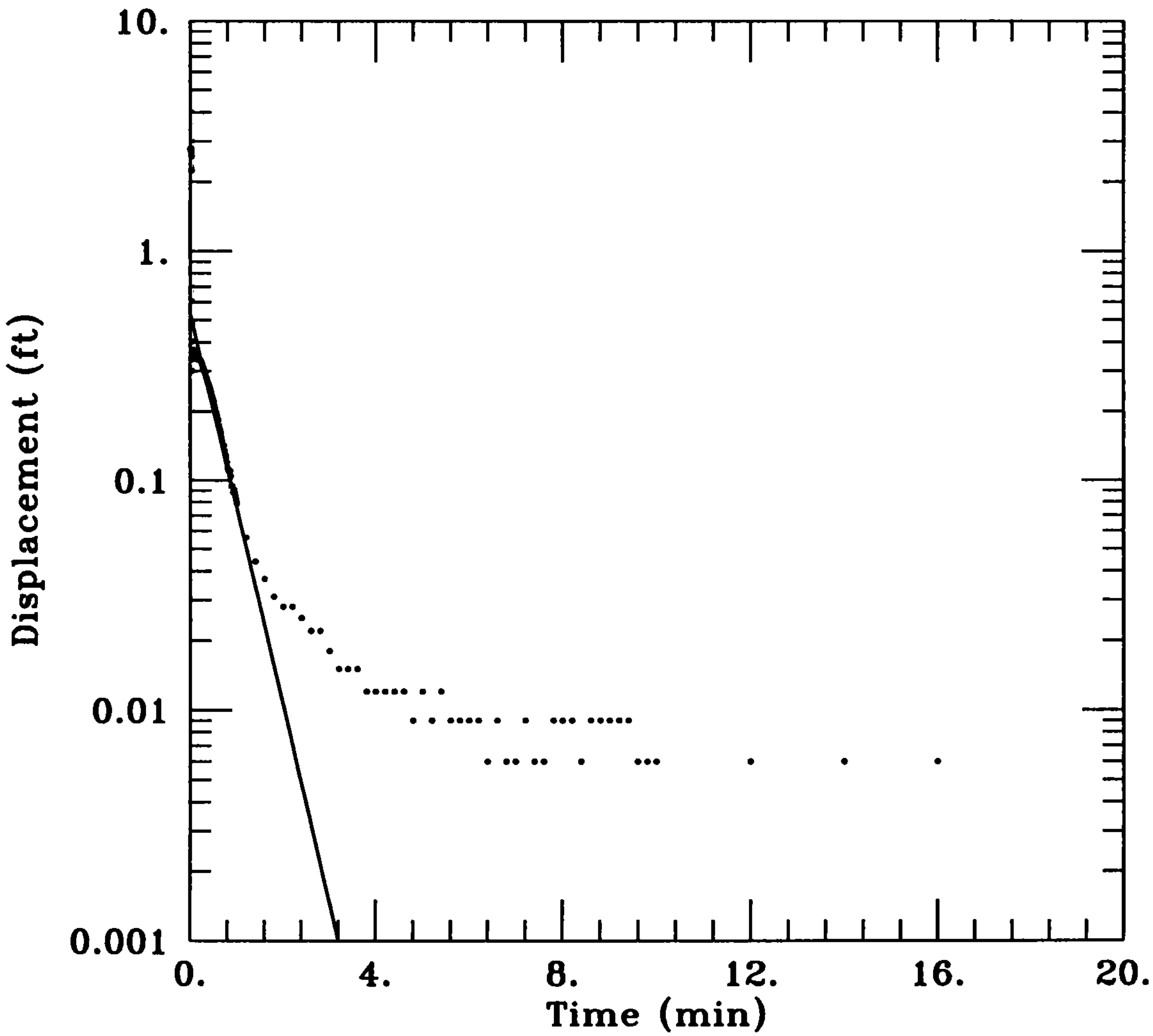
TEST DATA:
H0 = 3.82 ft
rc = 0.083 ft
rw = 0.35 ft
L = 7.8 ft
b = 7.8 ft
H = 7.8 ft

PARAMETER ESTIMATES:
K = 0.003752 ft/min
y0 = 1.364 ft

AQTESOLV

Client: **NAVBASE Charleston**	Company: **EnSafe/Allen & Hoshall**
Location: **Zone C**	Project: **2903-12210**

523-01



DATA SET:
52301FAL.AQT
01/16/96

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

PROJECT DATA:
test date: June 16, 1995
test well: Falling Head

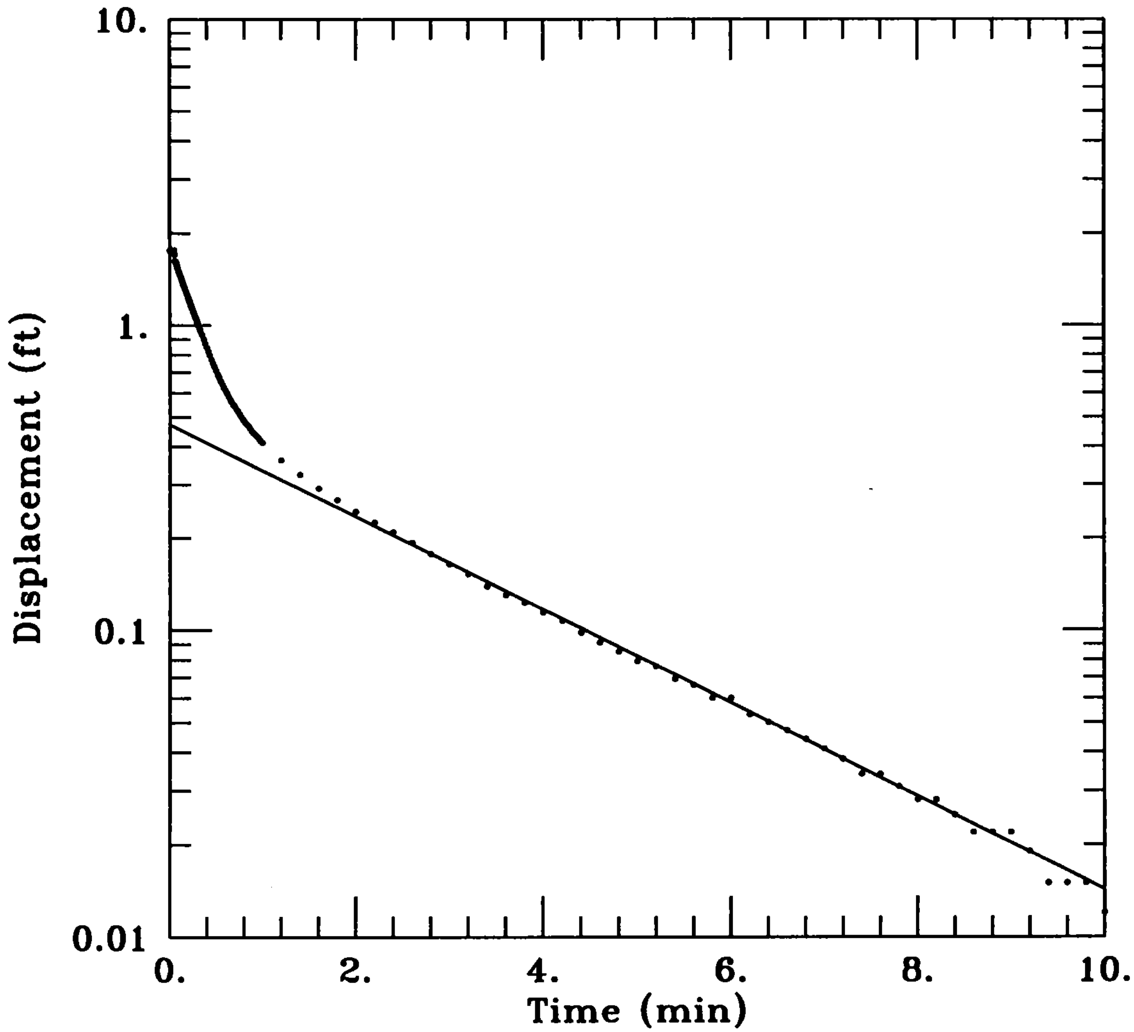
TEST DATA:
H0 = 2.77 ft
rc = 0.083 ft
rw = 0.35 ft
L = 7.8 ft
b = 7.8 ft
H = 7.8 ft

PARAMETER ESTIMATES:
K = 0.002004 ft/min
y0 = 0.5315 ft

AQTESOLV

Client: **NAVBASE Charleston**	Company: **EnSafe/Allen & Hoshall**
Location: **Zone C**	Project: **2903-12210**

GDC-01



DATA SET:
GDC01RIS.AQT
01/16/96

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

PROJECT DATA:
test date: June 16, 1995
test well: Rising Head

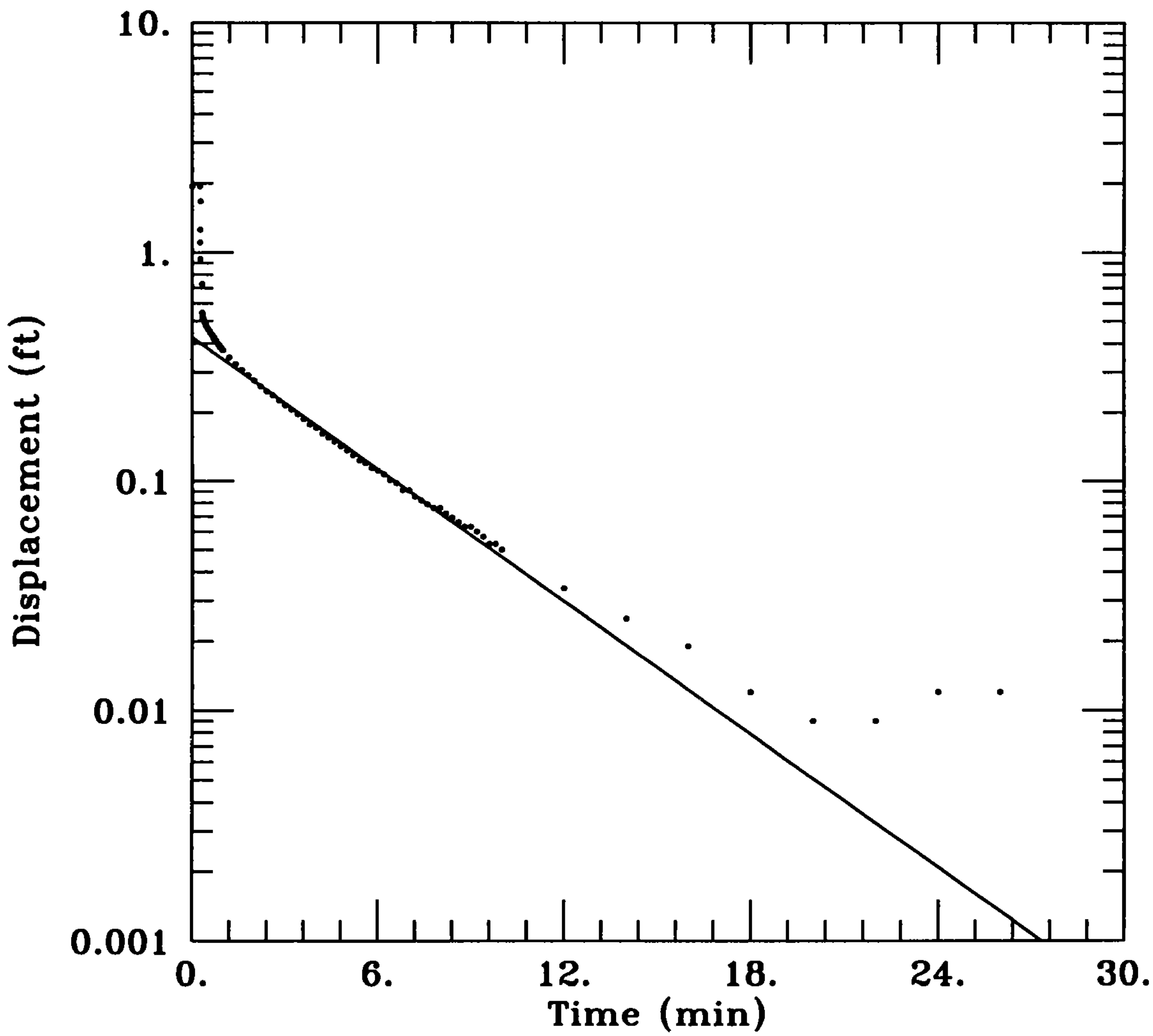
TEST DATA:
H0 = 1.76 ft
rc = 0.083 ft
rw = 0.35 ft
L = 3.4 ft
b = 3.4 ft
H = 3.4 ft

PARAMETER ESTIMATES:
K = 0.0005769 ft/min
y0 = 0.4726 ft

AQTESOLV

Client: **NAVBASE Charleston**	Company: **EnSafe/Allen & Hoshall**
Location: **Zone C**	Project: **2903-12210**

GDC-01



DATA SET:
GDC01FAL.AQT
01/16/96

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

PROJECT DATA:
test date: June 16, 1995
test well: Falling Head

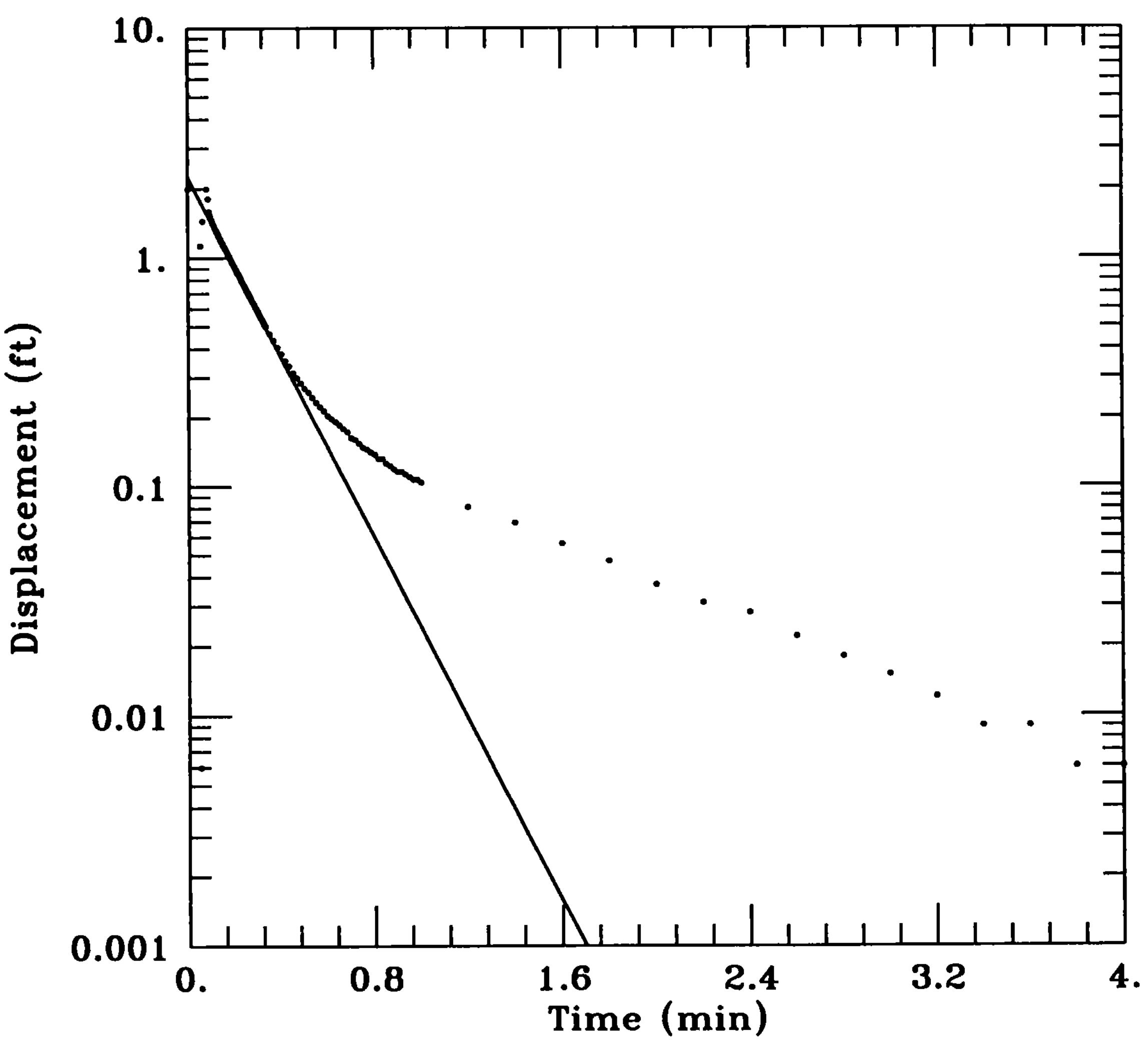
TEST DATA:
H0 = 1.94 ft
rc = 0.083 ft
rw = 0.35 ft
L = 3.4 ft
b = 3.4 ft
H = 3.4 ft

PARAMETER ESTIMATES:
K = 0.0003653 ft/min
y0 = 0.4256 ft

AQTESOLV

Client: **NAVBASE Charleston**	Company: **EnSafe/Allen & Hoshall**
Location: **Zone C**	Project: **2903-12210**

GDC-02



DATA SET:
GDC02RIS.AQT
01/16/96

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

PROJECT DATA:
test date: June 16, 1995
test well: Rising Head

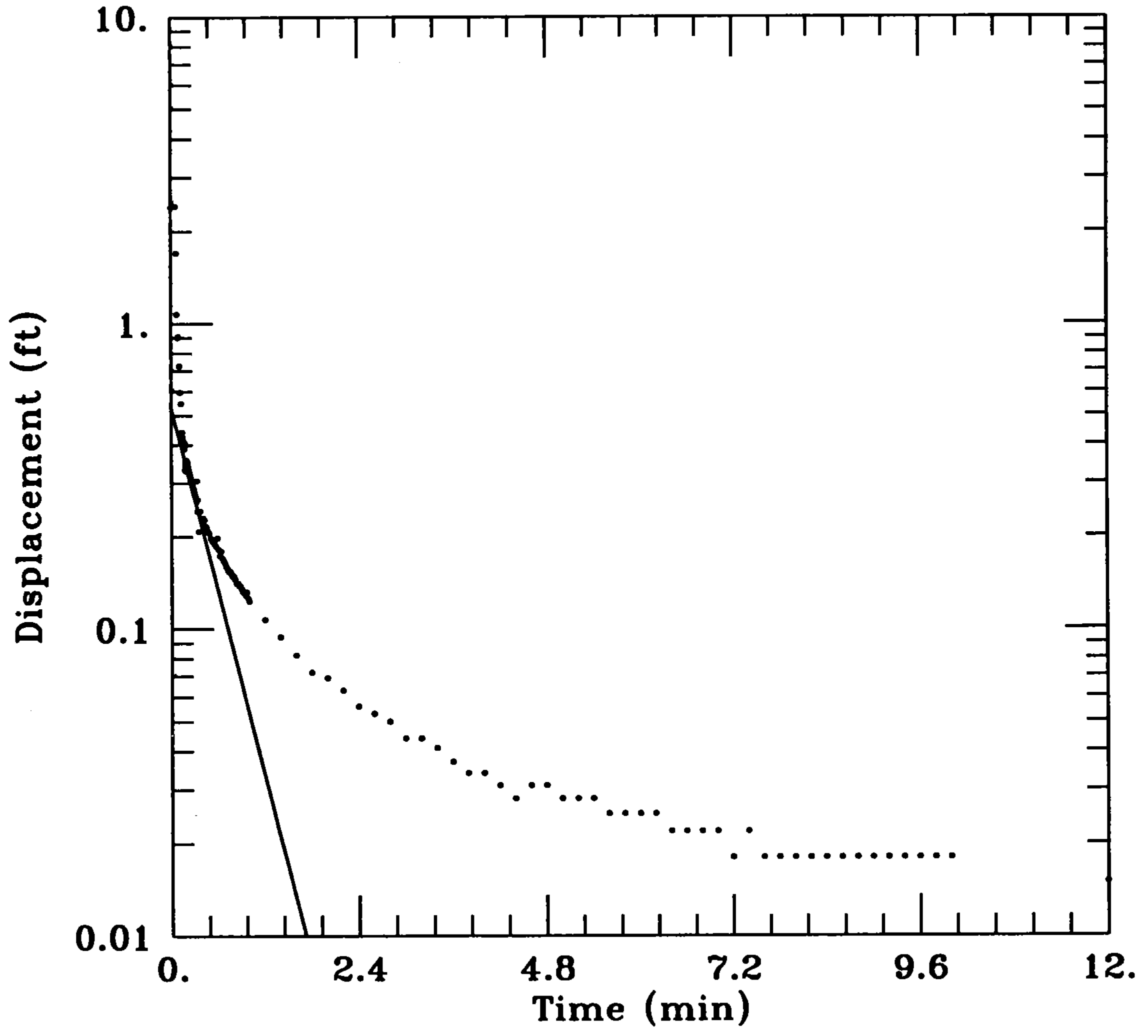
TEST DATA:
H0 = 1.99 ft
rc = 0.083 ft
rw = 0.35 ft
L = 7.6 ft
b = 7.6 ft
H = 7.6 ft

PARAMETER ESTIMATES:
K = 0.00471 ft/min
y0 = 2.237 ft

AQTESOLV

Client: **NAVBASE Charleston**	Company: **EnSafe/Allen & Hoshall**
Location: **Zone C**	Project: **2903-12210**

GDC-02



DATA SET:
GDC02FAL.AQT
01/16/96

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

PROJECT DATA:
test date: June 16, 1995
test well: Falling Head

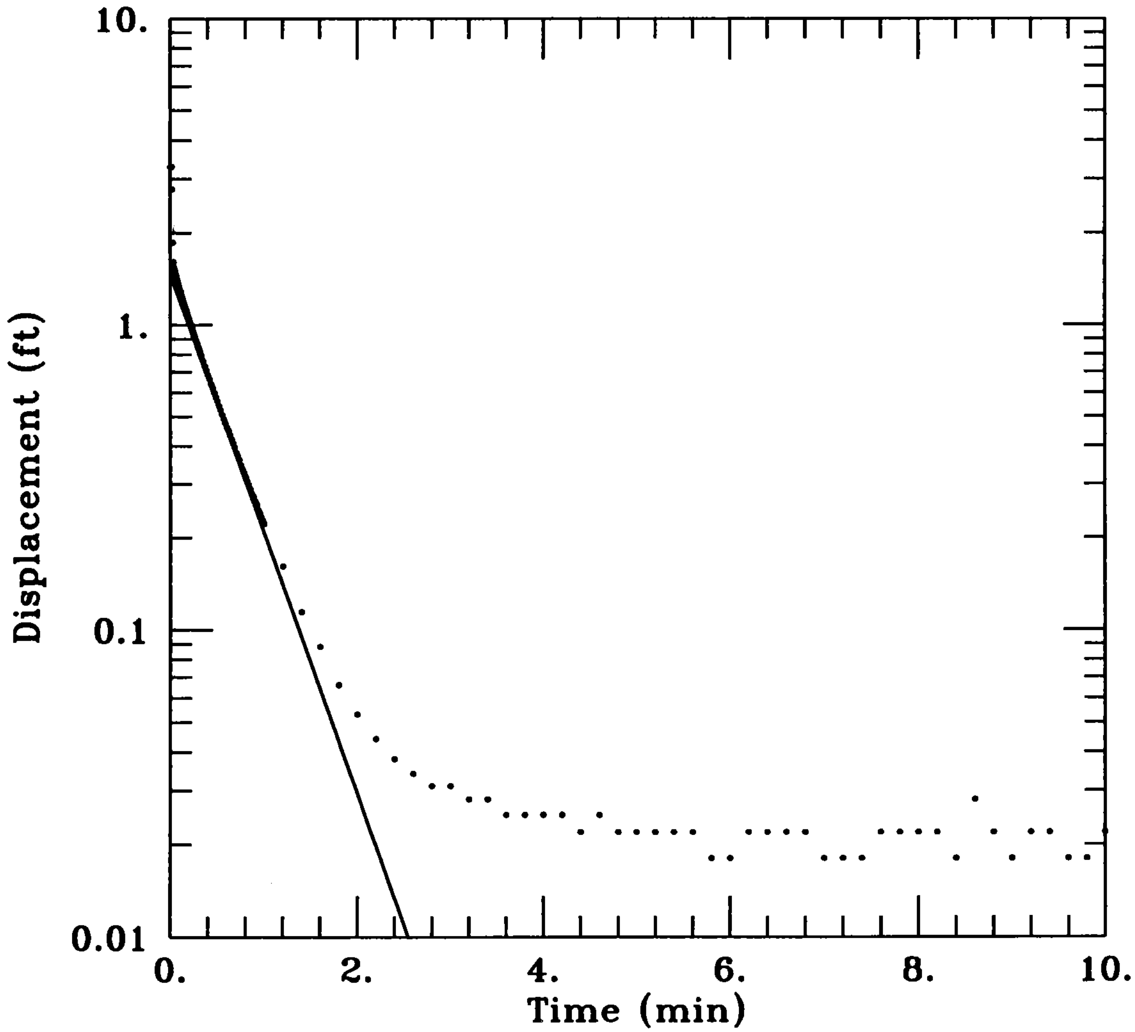
TEST DATA:
H0 = 2.4 ft
rc = 0.083 ft
rw = 0.35 ft
L = 7.6 ft
b = 7.6 ft
H = 7.6 ft

PARAMETER ESTIMATES:
K = 0.002395 ft/min
y0 = 0.5253 ft

AQTESOLV

Client: **NAVBASE Charleston**	Company: **EnSafe/Allen & Hoshall**
Location: **Zone C**	Project: **2903-12210**

GDC-1D



DATA SET:
GDC1DRIS.AQT
01/16/96

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

PROJECT DATA:
test date: June 16, 1995
test well: Rising Head

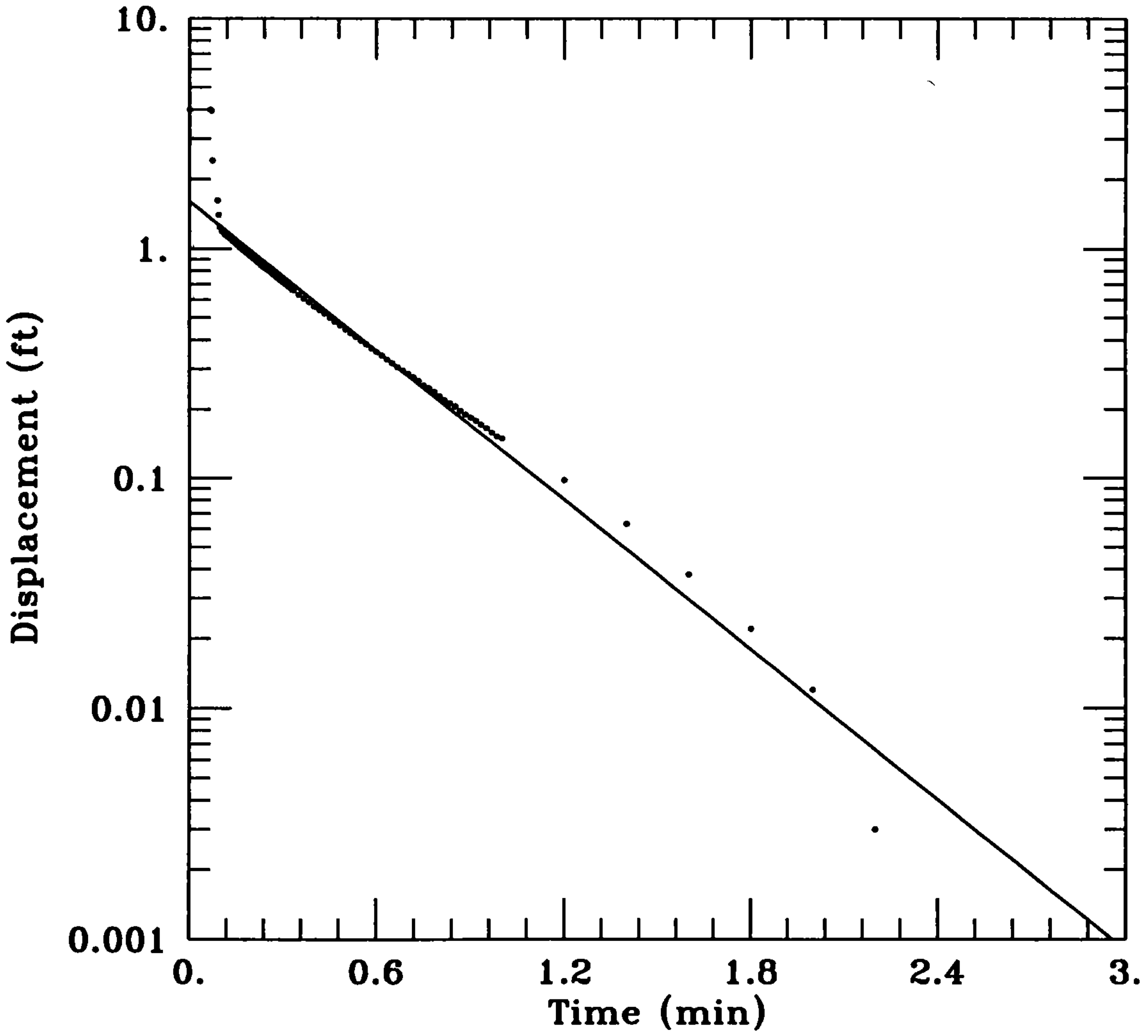
TEST DATA:
H0 = 3.28 ft
rc = 0.083 ft
rw = 0.35 ft
L = 10. ft
b = 26.8 ft
H = 26.8 ft

PARAMETER ESTIMATES:
K = 0.002099 ft/min
y0 = 1.456 ft

AQTESOLV

Client: **NAVBASE Charleston**	Company: **EnSafe/Allen & Hoshall**
Location: **Zone C**	Project: **2903-12210**

GDC-1D



DATA SET:
GDC1DFAL.AQT
01/16/96

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

PROJECT DATA:
test date: June 16, 1995
test well: Falling Head

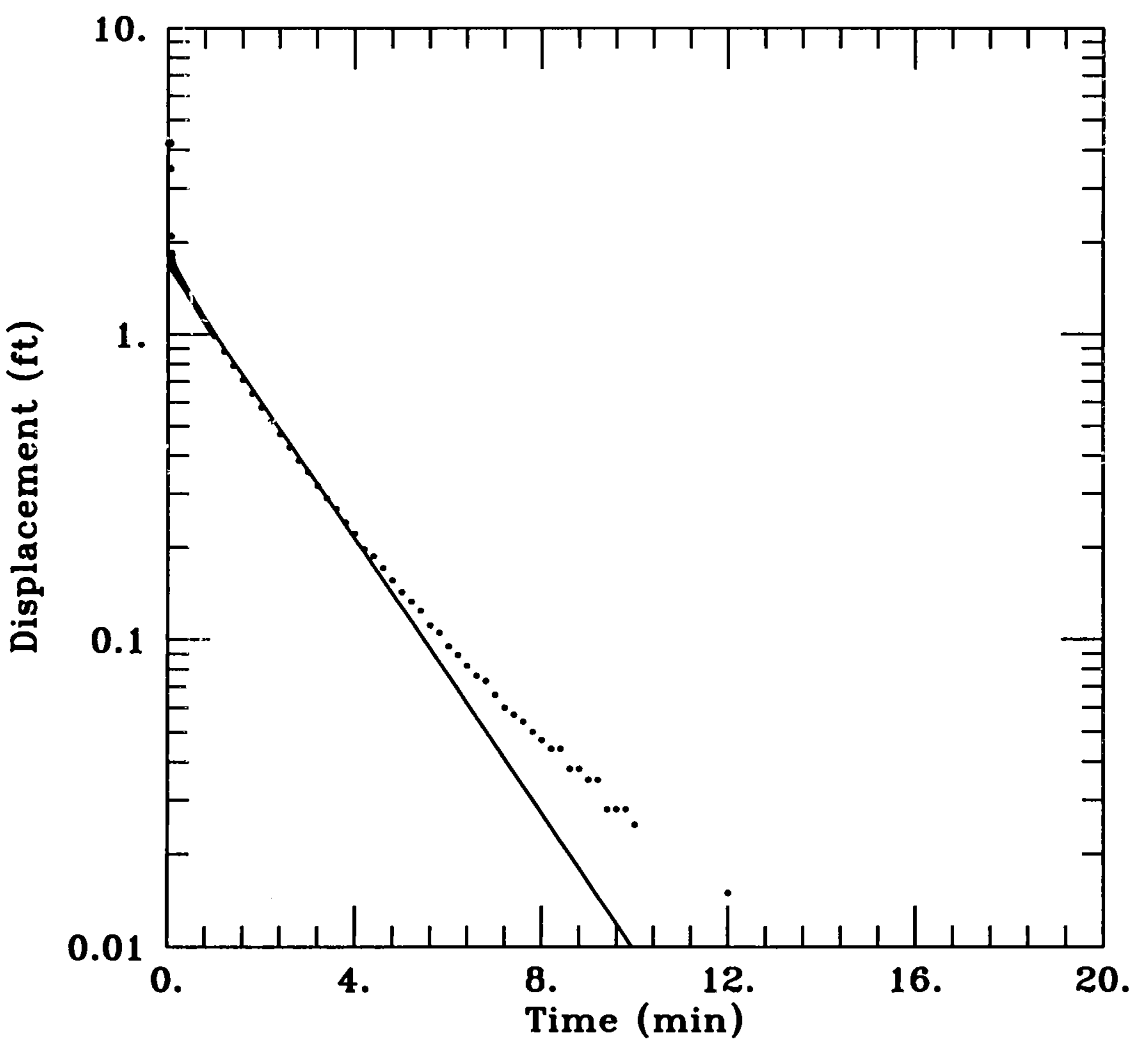
TEST DATA:
H0 = 3.99 ft
rc = 0.083 ft
rw = 0.35 ft
L = 10. ft
b = 26.8 ft
H = 26.8 ft

PARAMETER ESTIMATES:
K = 0.002677 ft/min
y0 = 1.6 ft

AQTESOLV

Client: **NAVBASE Charleston**	Company: **EnSafe/Allen & Hoshall**
Location: **Zone C**	Project: **2903-12210**

GDC-2D



DATA SET:
GDC2DRIS.AQT
01/16/96

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

PROJECT DATA:
test date: June 16, 1995
test well: Rising Head

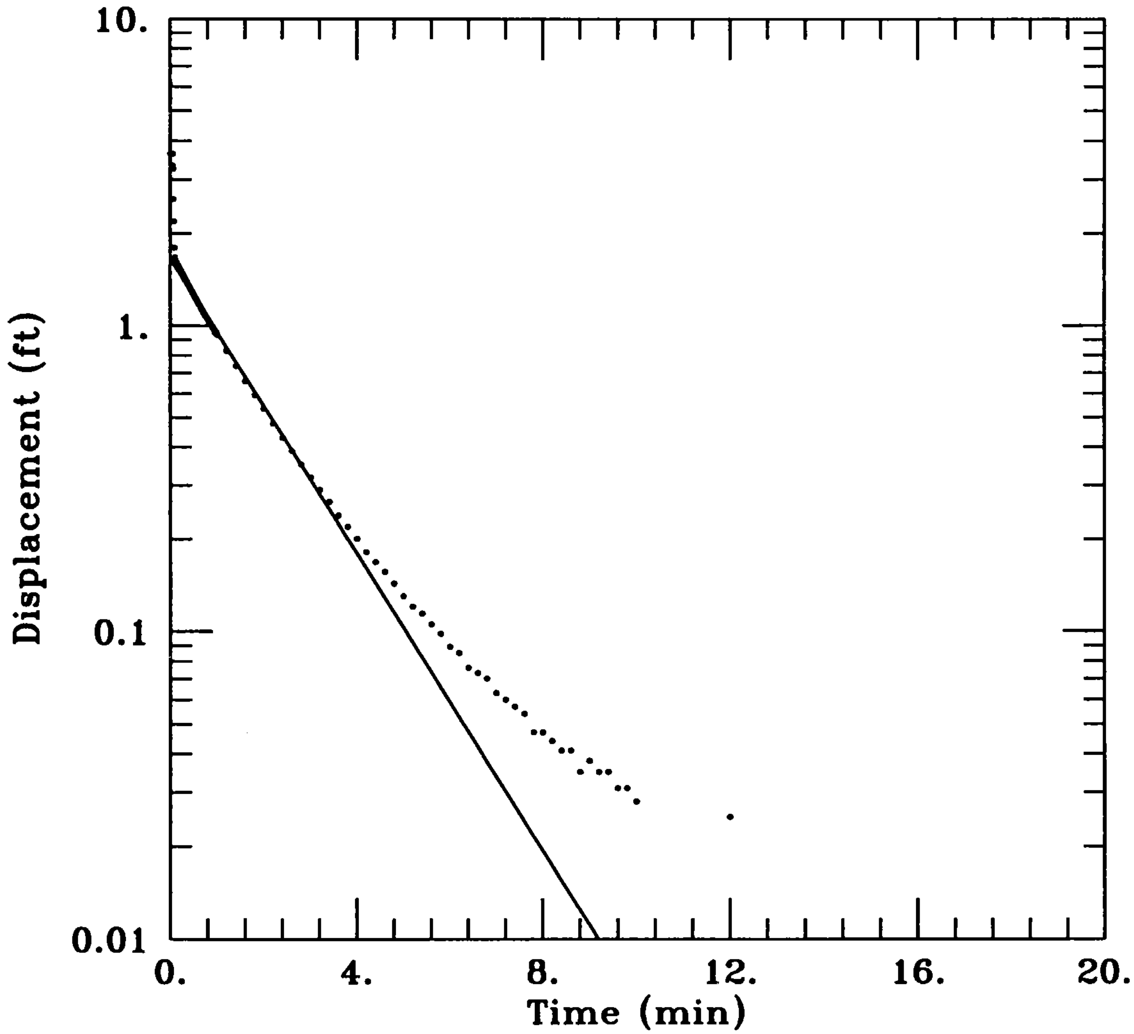
TEST DATA:
H0 = 4.19 ft
rc = 0.083 ft
rw = 0.35 ft
L = 10. ft
b = 65.5 ft
H = 65.5 ft

PARAMETER ESTIMATES:
K = 0.0006396 ft/min
y0 = 1.675 ft

AQTESOLV

Client: **NAVBASE Charleston**	Company: **EnSafe/Allen & Hoshall**
Location: **Zone C**	Project: **2903-12210**

GDC-2D



DATA SET:
GDC2DFAL.AQT
01/16/96

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

PROJECT DATA:
test date: June 16, 1995
test well: Falling Head

TEST DATA:
H0 = 3.63 ft
rc = 0.083 ft
rw = 0.35 ft
L = 10. ft
b = 65.5 ft
H = 65.5 ft

PARAMETER ESTIMATES:
K = 0.0006894 ft/min
y0 = 1.651 ft

AQTESOLV